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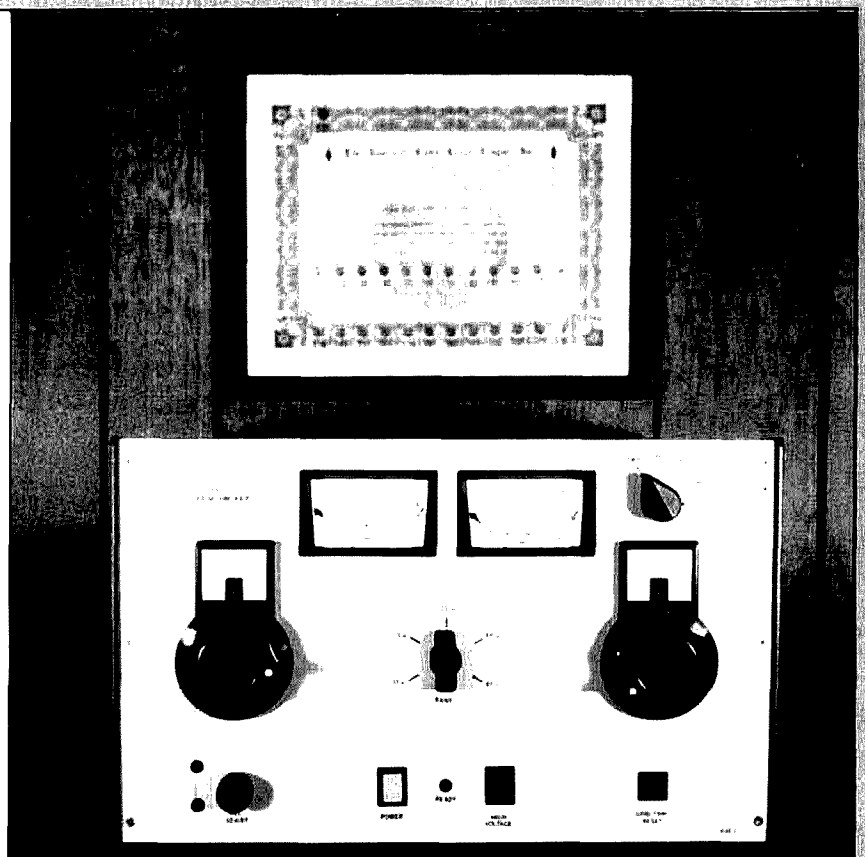
ham radio magazine

incorporating HAM RADIO HORIZONS

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modular linear *amplifier*

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JANUARY 1981

volume 14, number 1

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by Skip Tenney

The year **1981** is a year of great change and opportunity here at *ham radio*. We start off by welcoming as new readers the many thousands of subscribers to *ham radio's* former sister magazine, *Ham Radio Horizons*. These readers will be receiving *ham radio* each month on an issue-for-issue basis for the balance of their subscriptions (and, we hope, for many years after that). If you are one of our loyal supporters who took both magazines, then your *ham radio* subscription will be extended on the same issue-for-issue basis.

What are our plans for the combined magazine? Alf Wilson, W6NIF, our editor, will be explaining on page 6 in greater detail, but basically we intend to devote a major segment of each issue to keeping *ham radio* the pre-eminent technical publication in the Amateur field. At the same time, we plan to offer an interesting variety of new features derived from successful ideas that first appeared in *Ham Radio Horizons* — plus a few that are new to both publications. All of this material will be carefully chosen to make *ham radio* the most interesting and useful Amateur Radio magazine, both for the technically involved reader and the active but less technically oriented Amateur.

It all adds up to a big challenge for Alf and his staff, but he is well geared up for this project and I'm sure you're going to be seeing some of the best issues of *ham radio* that we've ever put out. Your comments will be of great value to us during this period of change. Don't hesitate to let us know your likes and dislikes, and also any other suggestions you may have.

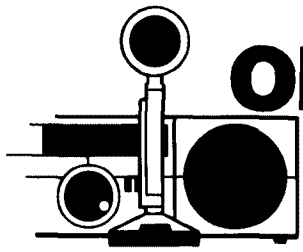
Many folks have been wondering why we stopped HRH, at a time when it was getting better and better with each issue and was showing such great promise. It wasn't an easy decision to make, especially in view of the fact that our readership kept growing stronger every month after our redirection of the magazine early last year. Our weakness was in the advertising column. As the newest of the major Amateur monthlies, *Horizons* never really got its share of the Amateur Radio advertising action. A new advertising sales team, which took over here last summer and had great luck in making *ham radio* grow, could not — despite their extensive efforts — keep the outlook for *Horizons* from deteriorating.

The answer soon became obvious. With the combination of our two magazines, *ham radio* now has the largest circulation of any of the independent Amateur magazines, and our new economics of operation allow us to give the advertiser a value unmatched anywhere else.

Everyone should benefit, because a strong magazine means a better magazine. Suddenly everyone here in the *ham radio* organization can double his efforts toward our one magazine.

This issue represents just the beginning of our new direction. It will take a few issues to really get the new format in place. We have a lot of good ideas, and by the time spring rolls around you'll be seeing the most interesting and best balanced magazine that has ever been offered to the Radio Amateur.

Skip Tenney, **W1NLB**



Observation & Opinion

As the new editor of *ham radio*, I've seen a number of changes occur in this organization. Some of these changes reflect difficult choices and decisions, but all of them have been made with the continued welfare of *ham radio* and its readers in mind.

The structure of the Ham Radio Publishing Group has changed. One of the best Amateur magazines in the world, *Ham Radio Horizons*, has been discontinued. The decision to drop *Horizons* was made with great reluctance. However, business is business, and *Horizons* just didn't pull its weight in advertising revenue, although the magazine flourished in the Amateur community. It provided many newcomers with down-to-earth information on operating techniques, easy-to-build construction projects, and an opportunity to get the feel of what Amateur Radio is all about.

ham radio, on the other hand, provides advanced Amateurs with the latest state-of-the-art developments in technology. It will continue to do so. So we have a dilemma: How do we keep *Horizons* readers interested in our product without turning off the old guard *ham radio* reader? It's a real challenge — one that is rare in the technical-publications business.

Our decision has been to expand *ham radio*, still retaining the best in communications technology but also including material for readers who have enjoyed *Ham Radio Horizons*.

In this issue you'll find two features that were standbys in *Horizons*: Bill Orr's "Ham Radio Techniques" and "DX Forecaster." The latter is a two-page summary of what's happening for the month in the DX world, including a propagation chart based on scientific observations. Bill Orr's column, which explores Amateur Radio from top to bottom, will be welcomed by every active Amateur, old and new.

Also in this issue are some subtle changes in magazine graphics. Our graphics designer, Bill Scarborough, has instituted some interesting methods of portraying the editorial material so that it's easier to read and much more pleasing to the eye. We think you'll like it.

Here's a brief description of the other new features you'll find in future issues of the new *ham radio*. "Questions and Answers" was extremely popular in *Ham Radio Horizons*. We plan to continue this feature. We also plan to include our "Owner's Survey," which is compiled from reader responses to questions about popular pieces of ham gear. This is probably one of the most unbiased reviews ever published in an Amateur Radio magazine. It's the kind of report that will never be prepared by a laboratory or in a manufacturer's test facility — it tells it like it is: no holds barred.

The DXer is very much a part of Amateur Radio. This fellow is unique. He will do just about anything to work a new country. In *Ham Radio Horizons*, Bob Locher, W9KNI, wrote on the trials and tribulations of the DX operator in his series, "DXer's Diary." Bob's easy-going literary style was much appreciated by *Horizons* readers. In a future issue of *ham radio*, we'll publish another of Bob's articles on DXing. We'd like to hear from readers as to how they like this feature. If the response is positive, we'll continue "DXer's Diary"; if not, we'll drop it. Let us know what you think. It's your magazine. We'll do our best to publish articles that appeal to the most readers.

We're trying to provide the best balance of articles ever published in an Amateur Radio magazine. Let us know your desires and needs. We welcome all suggestions.

Alf Wilson, W6NIF
Editor

presstop

HAM RADIO HORIZONS ceased publication with the December, 1980, issue. Though Ham Radio Horizons had succeeded in building a loyal and ever-increasing following of Amateur Radio readers, it had not achieved sufficient popularity with advertisers to put it into a very solid financial position. That, coupled with Horizons' pulling of some ad revenue from its parent publication, Ham Radio, and the current spottiness of the Amateur Radio marketplace, led to the decision to concentrate both editorial and marketing efforts of the staff on the older, more successful and better known magazine.

Ham Radio Horizons Subscribers will receive Ham Radio on an issue for issue basis; the 25 per cent or so who now receive both publications will have their Ham Radio subscriptions extended proportionally. Adding the unduplicated Horizons subscribers to Ham Radio will increase that magazine's subscriber list to more than 75,000. As a result, Ham Radio advertisers will, for the moment, be getting the best bargain in the Amateur Radio field.

Though The Shutdown after four years of publication is a disappointment to both Ham Radio Horizons' staff and its many loyal readers, it provides the necessary resources to ensure that Ham Radio will maintain its well entrenched position as Amateur Radio's top technical publication. In addition, Ham Radio's editorial coverage will be broadened somewhat by adding to it some of the more popular features for Ham Radio Horizons.

SIGNIFICANT IMPLICATIONS FOR AMATEUR RADIO can be inferred from Ronald Reagan's smashing victory in the presidential elections. The effects will be felt almost entirely through the FCC, which Washington observers feel will retreat sharply from the recent liberal philosophy under Chairman Ferris that led to directions blurring the distinctions between Amateur Radio and CB.

The Transition Won't Occur quickly, however; Dick Wiley was FCC Chairman for almost a year after Jimmy Carter won the presidency in 1976, while the new president tended first to higher priority changes in the Washington hierarchy. During the interim period, expect the Commission to move very slowly, avoiding any appearance of "making waves."

Though This May Mean Delays in implementing some needed rule making and even access to the new 10.1 MHz band, the more conservative Reagan administration is expected to return Amateur Radio's direction to more traditional paths than it has recently been on.

220 MHZ IS AGAIN BEING EYED by other services, according to current rumors from Washington. Users of the inland waterways system are reported to be looking at 220-225 MHz to relieve the congestion they're presently experiencing on the 160-MHz marine band, possibly at the suggestion of someone within the FCC!

Placing Inland Waterways Communications on 220-225 MHz came up earlier this year in FCC General Docket 80-1, an NPRM that was issued in response to the waterways users' request for more 150-170 MHz channels, suggesting 216-220 or 806-890 MHz for alternatives. The problem with that NPRM came in its summary, which cited 216-225 MHz instead of 216-220 MHz for expansion. After discussing the discrepancy with Amateur Radio representatives (and a storm of protests from 220 users), the FCC did issue a correction, but there was then and certainly is now some suspicion that inclusion of the 220 MHz Amateur band in the FCC's proposal was more a trial balloon than an error.

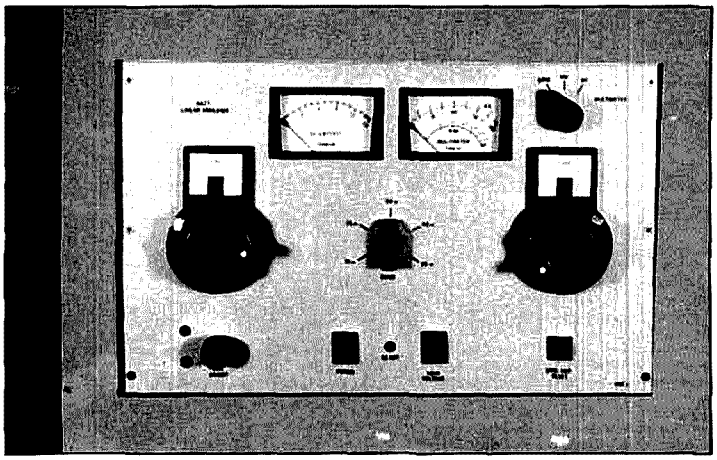
The ARRL Is Well Aware of this new threat, and is planning a determined campaign to quash it. Still another threat is brought out in the December, 1980, issue of Popular Electronics, in an article on cordless phones which says that manufacturers are looking to the FCC for new frequencies in either the 27 or 220-225 MHz band!

A PROBE INTO AMATEUR LICENSING IMPROPRIETIES dating back to 1976, when the August 15 issue of the Indianapolis Star ran a long article headlined "FBI PROBES HAM RADIO SCANDAL," is finally coming to a head. In a November 6 release, the Private Radio Bureau Chief ordered 13 Amateurs, 10 of them from Indianapolis or vicinity, to show cause why their station licenses should not be revoked, and suspended their operators licenses. Another, whose license is up for renewal, is under review.

All Of The 14 Are Alleged to have "fraudulently obtained or attempted to obtain new or upgraded Amateur licenses without examination" or "actively participated to fraudulently obtain or attempt to obtain new or upgraded Amateur licenses without examination" by the Commission in PR Dockets 80-668 through 80-682.

PLAIN LANGUAGE AMATEUR RULES GOT the Commissioners' nod recently along with some nice comments about both the Amateur Service and the staff's work on the rewrite job. The proposed new Part 97 has four parts: Part A, The Amateur Radio Service; Part B, The Radio Amateur Civil Emergency Service; Part C, The Amateur Satellite Service; and Part D, Technical Standards common to all three services.

Three Important Changes are in the proposed new rules. One: All previous log keeping requirements are deleted. Two: The Communications Act Section 303 requirement that an Amateur make his station available to the Commission for inspection will now be incorporated in the new Part 97. Three: Every Amateur would be required to keep a copy of Part 97 in his station.



modular linear amplifier

for the high-frequency Amateur bands

Genesis of an 8877 amplifier — an example of Amateur craftsmanship

Many articles have been published on linear-amplifier construction. The reason is that an rf linear amplifier is one relatively simple, technical project the average Amateur can build that can rival the best commercial units on the market. The amplifier described here was inspired by the excellent series on amplifier design by Bill Orr, W6SAI,[1] combined with my desire to try some new ideas. The results of the project are illustrated and discussed below.

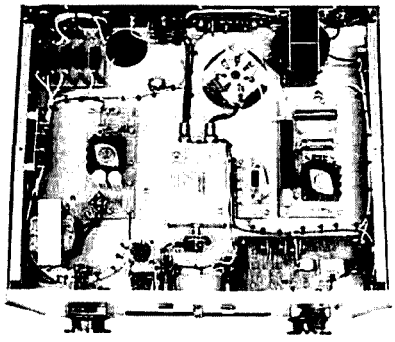
The amplifier was built for a friend, Steve, K8EJ, who wanted a "clean" amplifier built around the Eimac 8877 ceramic metal triode. Steve supplied all financial backing in return for a design that provided excellent performance and maintenance as well as reliability. These objectives have been met. I hope that the results of this project will encourage others.

preliminary building tips

After designing and building several different amplifiers, I've come to some basic conclusions and recommendations which I feel are worth consideration. First of all, build the amplifier *right* the first time! If you compromise anywhere, you'll not be happy with the product in the long run. Granted, it will cost more money and take more time and effort, but you'll be more gratified with the final results. For example, buy a commercial cabinet. Spend $35.00 each for nice meters with lighting kits. Buy a good, heavy filament transformer and quality pushbutton switches. Use Teflon wire and plenty of cable ties to bundle the cable harnesses.

Most important, *plan* your design. This is extremely important. (I spent time on this project drawing circuits, laying out the front panel, rear panel, and chassis.) Build the amplifier in *your mind* before you drill the first hole. Also, modularize the design and test as many of the modules as possible as they're constructed. Take the time to learn how the unit works. Study the technical details, and enjoy the project as a creation to be proud of, developed by your own hands.

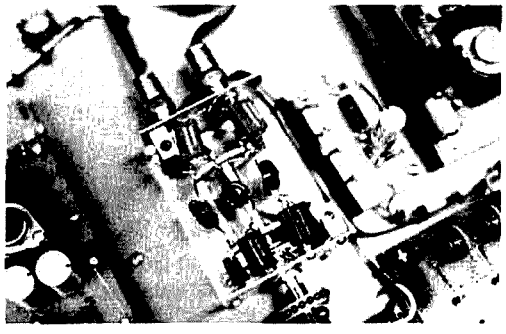
By Jerry Pittenger, K8RA, 2165 Sumac Loop South, Columbus, Ohio 43229



Amplifier bottom view. The modularization is evident here. Refer to fig. 3 for identification of each module.

circuit design

This amplifier (**fig. 1A**) is designed around the popular Eimac 8877 high-mu power triode. The 8877 was selected for its low drive requirements (that is, 50 watts drive for 2 kW PEP), its compactness, and the clean operating characteristics* exhibited by the tube.



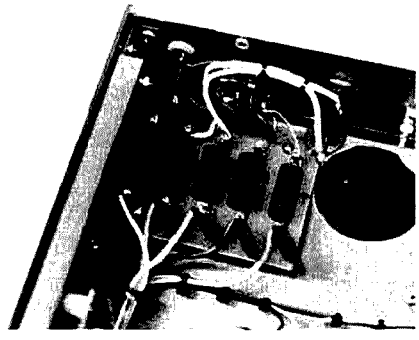
Tuned input network. Component values are:

band	CT (pF)	LT (μH)
80	860	3.23
40	445	1.67
20	225	0.84
15	150	0.56
10	112	0.42

band	core	wire size	turns
80	T50-2	22	20
40	T50-2	18	14
20	T50-6	18	10
15	T50-6	16	8
10	T50-6	16	6

*Refer to Eimac Bulletin 3950, which is the technical data sheet for the 8877 (3CX1500A7).

The amplifier uses a tuned input, which is ganged to the main band switch, and an effective ALC circuit (**fig. 1B**) to prevent overdriving the tube. The ALC level is adjustable from the front panel. Drive conditions can also be monitored by a pair of LEDs located on the front panel lower left corner. One LED is green and begins to flash with approxiately 50 mA of grid current. The other LED, red, begins to flash at approximately 150 mA grid current; thus, the LEDs provide a convenient way to monitor instantaneous grid current, which cannot be accomplished with metering circuits because of the slow response of meter movements.



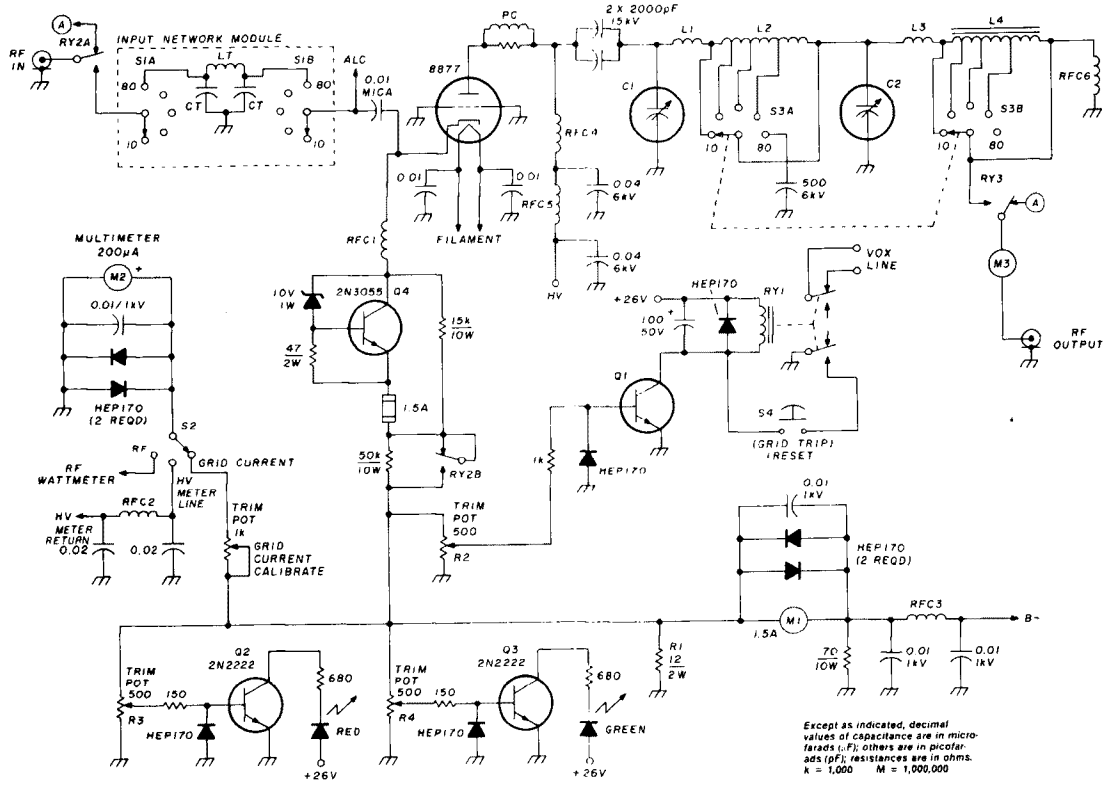
Lead filtering. All leads entering and leaving the amplifier rf deck are filtered using a pi-section network. Leads include 110 Vac coming to the amplifier, and 110 Vac returning to the power supply; a high-voltage metering line, a B- lead, and a chassis ground lead.

The amplifier also has a very effective grid-trip circuit, which snaps the amplifier out of the transmit line should the grid current exceed 200 mA. This feature protects the tube if the antenna is disconnected or if the tube should flash over for any reason. The grid trip circuit is reset for normal operation by pushing the GRID TRIP RESET button on the lower front panel.

The amplifier uses a vacuum relay on the output because of its quiet operating characteristics, compactness, and power-handling capability. Also, vacuum variable capacitors are used for both tune and loading controls in a pi-L output matching network.

Included also is a built-in rf wattmeter and a time-delay circuit, which keeps the blower on for about two minutes after the amplifier is turned off to ensure cooling.

The amplifier shown in the photos was built in a

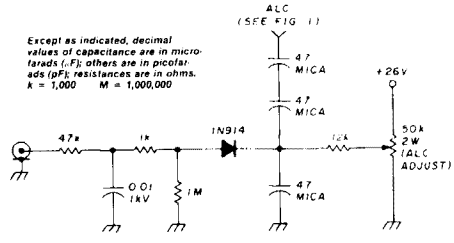


Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms. k = 1,000 M = 1,000,000

C1	370-pF, 15-kV Jennings vacuum variable
C2	1000-pF, 3-kV Jennings vacuum variable
CT/LT	tuned input network *
cabinet	Intra Fab Inc., 10" x 17" x 14" (25.4 x 43.2 x 35.6 cm)
chimney	Eimac SK2216
Counter dials	Bauman TC3-S
L1	10-meter, 1/4-inch (6.5-mm) silver-plated copper tubing 1 3/4" diameter five turns tapped on third turn.
L2	15-80 meter, 1/4-inch (6.5-mm) silver-plated copper tubing 3 1/8" (10.6 cm) diameter nineteen turns tapped — one turn, 15 meters; five turns, 20 meters; twelve turns, 40 meters; nineteen turns, 80 meters.
L3	10-meter L-coil No. 14 (1.6 mm) wire — five turns, 3/4-inch (19-mm) diameter
L4	toroid 2/T200-6 cores No. 14 (1.6 mm) Teflon sleeved wire, seventeen turns tapped — one turn, 15 meters; three turns, 20 meters; nine turns, 40 meters; seventeen turns, 80 meters.
M1	Simpson "Wide VUE" 3 1/2-inch (8.9-cm) 1.5A model 1327 including 01253 mounting bezel and 01165 illumination kit
M2	Simpson "Wide VUE" 3 1/2-inch (8.9-cm) 200-μA model 1327 including 01253 mounting bezel and 01165 illumination kit
M3	Wattmeter (see fig. 5).
PC	three 150-ohm, 2-watt carbon resistors in parallel shunted across one turn of 3/8-inch (9.5-mm) plate strap
Q1	NPN — 2N3054
RFC1	110 turns No. 22 (0.6-mm) enameled, on 1/2-inch (12.7-mm) diameter nylon rod (~ 28 μH)
RFC2, RFC3	twelve turns No. 16 (1.3-mm) enameled, 3/8-inch (9.5-mm) diameter
RFC4	200 turns No. 24 (0.5-mm) enameled, 7/8 inch (22-mm) diameter nylon rod (~ 180 μH)
RFC5	twelve turns No. 14 (1.6-mm) enameled, 3/8-inch (9.5-mm) diameter
RFC6	1-mH, 0.3A rf choke
RY1	4pdt Potter & Brumfield KHU17D11, 24 Vdc coil
RY2	KA11DG Potter & Brumfield dpdt, 24 Vdc coil
RY3	PB2 Jennings vacuum relay
S1	two-pole, six-position, 60° indexing Centralab 2045
S2	one-pole, three-position, Centralab 2003
S3	radio switch model 86, two-pole, six-position, 60° indexing with sleeve bearings
S4	Arrow Hart momentary pushbutton switch actuator AH83502, contact block AH83500-30, lense AH83500-84
socket	see text or substitute Eimac SK2210

fig. 1. Schematic of the modularized linear amplifier rf deck (A).

*Only one network shown for clarity. See table on page 13 for CT/LT values.



Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms. k = 1,000 M = 1,000,000

fig. 1. Automatic level control schematic (B).

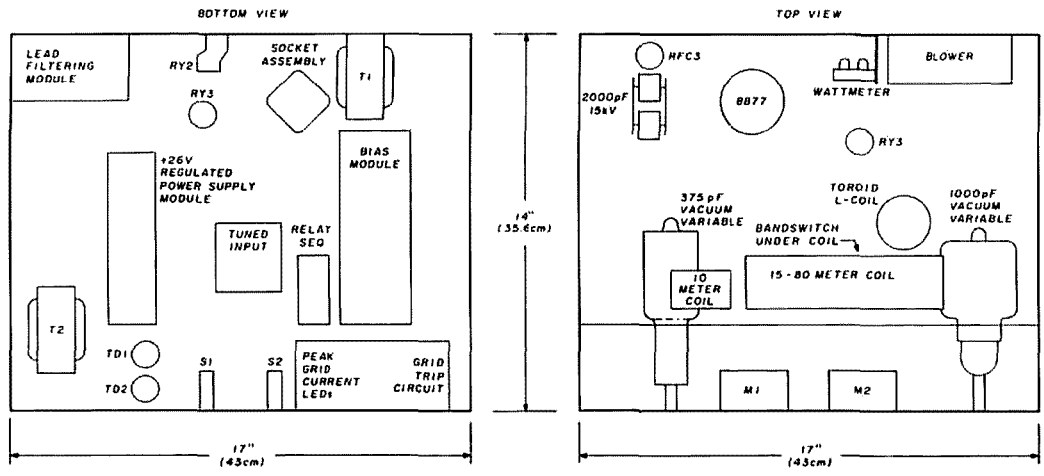


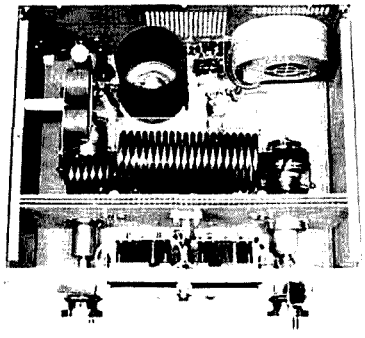
fig. 2. Modular component layout.

modularized fashion. Fig. 2 shows the location of each module below and above the amplifier chassis. The major modules are discussed.

amplifier control circuit

The control circuit (fig. 3) provides the power control for operation of the amplifier. Ac power is received from the amplifier power supply in this design. Actuating the POWER ON button on the front panel turns on the blower, the tube filaments, and initiates a three-minute warm-up sequence for the 8877. Time delay is accomplished using an Amperite time delay tube, which provides a reliable timing circuit. The Amperite delay tube has a normally open set of contacts, which close after the designed period of time after 110 Vac has been applied to the delay-tube coil. The POWER ON button also activates the 26 Vdc regulated power supply to light the meters and POWER ON front panel push button. Note that the amplifier can't be keyed up until the required warm up time has elapsed (S2B). When three minutes have elapsed, the READY LED, located at the bottom center on the amplifier front panel, lights. The HIGH VOLTAGE front-panel pushbutton can then be pressed, which results in 110 Vac applied to the power supply to actuate the step start relays, which turns on the high voltage. Note that activating the HIGH VOLTAGE switch before the READY light comes on results in no action.

The 26-Vdc power supply uses an LM317 voltage regulator chip, which is readily available. A regulated supply was used to avoid having the pilot lights and meter lights dim when the amplifier is keyed up.



Amplifier top view. All metering circuits are isolated from the rf section using a subpanel. The subpanel is used to mount the bandswitch and the two vacuum variables.

input network

The amplifier input network is designed for a $Q = 1$ and is enclosed in a self-contained shielded module. The design departs somewhat from conventional designs in that toroids are used instead of slug-tuned coils. Initially, there had been concern that the ferrite cores would saturate at the given drive powers, but this proved not to be a problem. I've used this same module in two other amplifiers with great success. The advantages are obvious. The toroids are compact and can be suspended right into the network bandswitch for easy mounting.

The rf enters and leaves the input network through BNC connectors. Since the nominal input impedance

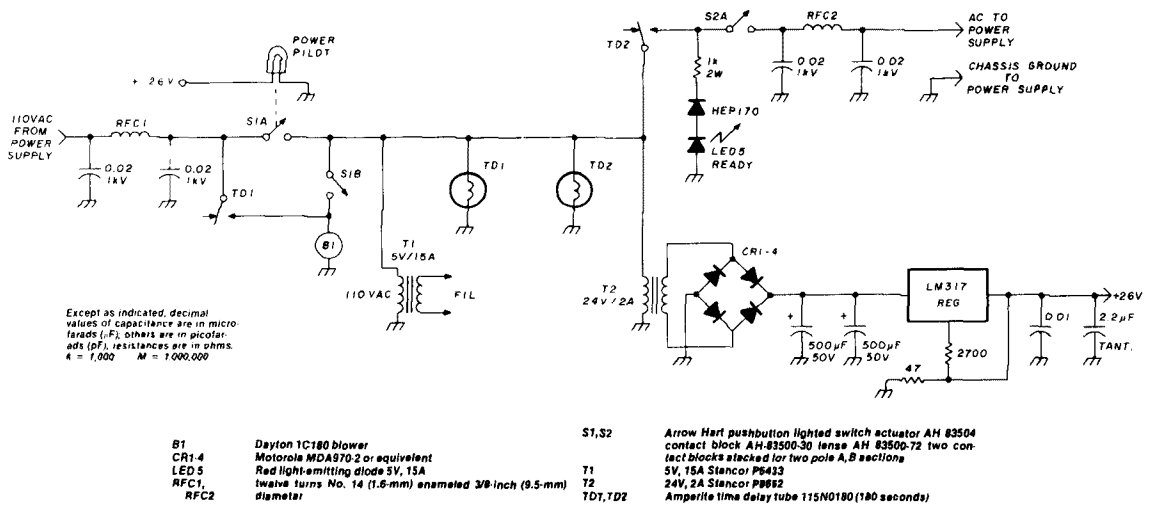


fig. 3. Amplifier control circuit.

of the 8877 is approximately 60 ohms, the module can be tested separately by connecting it in series with a 50-ohm dummy load. Initially, I used plenty of inductance on each core, then removed one turn at a time to obtain a flat SWR across each band with the fixed micas used. The input network is connected to the main bandswitch using a bead chain sprocket.*

grid-trip circuit

The grid-trip circuit automatically causes the amplifier to drop out of the rf line when the grid current reaches a specific level. It's a great feature and operates as follows.

Grid current is drawn through the 12-ohm, 2-watt resistor, R1, developing a voltage drop across the resistor, which turns on transistor switch Q1 (**fig. 1**). The amount of grid current drawn through R1 to turn on Q1 is determined by the voltage divider created by trim pot R2. When Q1 turns on, current is drawn through the grid-trip relay coil, RY1, which actuates the relay. Three sets of relay contact on RY1 are used. One set sends 26 Vdc to the pilot light on the GRID TRIP RESET normally closed momentary switch located on the front panel, which indicates that the grid trip has been actuated. A second set of contacts (normally closed) break the VOX line, resulting in amplifier standby mode. The third set of contacts provide a path to ground for RY1, so it remains closed. The GRID TRIP RESET switch deactivates RY1, which puts the amplifier back into the ready mode. Of course, you should check loading conditions to determine the problem that resulted in the excessive grid current.

*Available from Small Parts, Inc., 6901 N.E. Third Avenue, Miami, Florida 33128. Ask for their catalog. They have a wealth of hard-to-find parts available in small quantities.

peak LED grid current indicators

The peak grid current indicators operate on the same principle as the grid trip reset circuit discussed previously. The voltage generated across R1 turns on transistors Q2 and Q3, which operates the red and green LEDs respectively. Voltage dividers R3 and R4 provide a way to adjust the grid current levels at which the LEDs turn on. I recommend that the LEDs be turned on at approximately 150 mA (red) and 50 mA (green) respectively. In proper operation, the drive power should be controlled using the ALC adjustment to allow the green LED to just start flashing on voice peaks. Any flashing of the red LED indicates either excessive drive power or improper loading-control adjustment in the pi-L circuit.

lead filtering

All control cables between the amplifier rf deck and the power supply are filtered before entering or leaving the rf deck. This will minimize any rf leakage, which might cause RFI. The filters are mounted on a separate module and use a pi-network section. Make the leads from each pi section as short as possible to the rear-panel connector.

operating bias circuit

Operating bias is generated using a high-power 2N3055 NPN transistor (Q4) which, with the 1-watt zener, acts as a high-power zener (see **fig. 1**). This circuit includes readily available components and

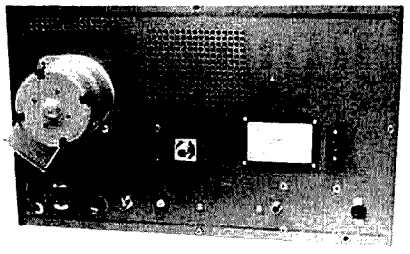
provides an easy way to adjust the bias voltage merely by changing the 1-watt zener between the collector and base of Q4. The bias should be adjusted to give approximately 180 mA idle current for the plate voltage used.

blower delay circuit

When the amplifier is turned off, the blower remains on for about two minutes. This is accomplished with an Amperite three-minute time delay relay (TD1). The Amperite time delay operates by heating a resistive coil, which acts as a filament, to heat a thin strip of metal, causing it to bend, thus closing two relay contacts. I found that the three-minute Amperite unit required about two minutes to cool after the power had been removed to the point that the relay contacts open. This delay keeps the blower on after the amplifier is turned off. Note that S1B turns on the blower immediately with the filaments.

in/out relay sequencing

When keyed up, the amplifier closes both an input open-frame relay and an output vacuum relay. The relays must be sequenced to ensure that the output vacuum relay is closed before any drive power reaching the tube. Should the output relay close second, the amplifier would be placed in operation for a short period without a proper 50-ohm load. This condition could be harmful to the 8877 tube. **Fig. 4** illustrates the timing circuit that accomplishes proper relay sequencing. Capacitor C1 determines the length of delay on the input relay. Usually the delay can be detected by your ear.



Amplifier rear view. The holes in the rear panel are for air intake to the blower. The 10-pin Cinch Jones connector is for the control cable running to the high-voltage power supply. Rf input is through the BNC connector, and the rf output is through the type N connector. The high-voltage connector is a Millen 37001. The phono plug provides ALC to the exciter. The two-pin Cinch Jones connector is the VOX line to control keying up the amplifier in transmit mode.

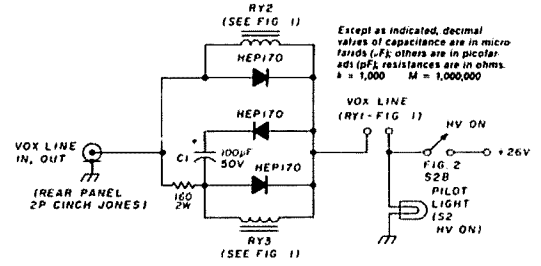


fig. 4. Amplifier relay sequencing schematic.

pi-L matching network

The pi-L network was selected because of its improved harmonic attenuation characteristics over a regular pi-network. The inductance values depend on the tube plate impedance, which is based on the operating conditions of the tube and the selected network Q. The plate impedance is determined by:

$$I = \frac{V_p}{(1.6)(I_p)} \qquad (1)$$

where I = plate impedance (ohms)
V_p = plate voltage (volts)
I_p = plate current (amperes)

Given the plate impedance, I, component values in the pi-L network are available for a Q of 12 from tables published in the literature.[2]

I recommend that the L coil be shielded from the pi coil for most efficient operation. Therefore, a toroid coil was used for the L section in this amplifier. A toroid has the inherent advantage of being self-shielding. The toroid L coil also has the advantages of compactness. The pi-coil is wound from 1/4-inch (6.4 mm) diameter soft copper tubing that has been silver plated.*

Taps on the coils always seem to be a troublesome detail for many builders. A way I've found to be successful in determining tank-circuit inductance is this:

1. Mount the coils into the amplifier but disconnect the tube end of the coil network and the plate and load vacuum-tuning capacitors.

2. Obtain a high-tolerance mica capacitor (selected for its low-inductance properties). Connect one lead to the tube-end of the network. With a very short piece of wire, connect the other lead to the coil turn at which the inductance is to be determined.

*Custom-made coils may be obtained at nominal charge. Send a SASE for details to the author.

3. Use a grid dip meter to determine network resonant frequency.

4. Determine the coil-tap inductance from:

$$L = \frac{10^6}{2\pi^2 f^2 C} \qquad (2)$$

where L = inductance (μH)
f = frequency (kilohertz)
C = capacitance (pF)

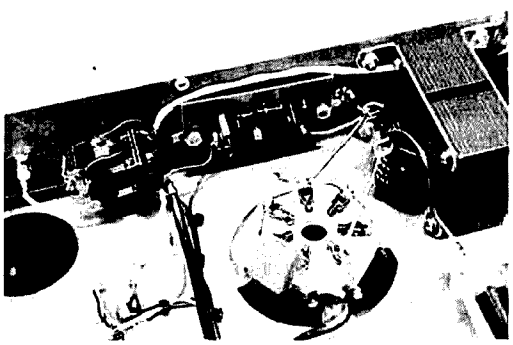
5. Set taps according to inductance values for the circuit Q selected ($Q = 12$ is recommended).

Remember that these data provide approximate inductance values, since the leads to the bandswitch will also affect inductance. I've found that slightly less inductance from the values determined by the procedure above should be used for 10 and 15 meters.

cooling

I have only *one* recommendation concerning amplifier cooling, and that is use plenty of it! Excessive heat will destroy a vacuum tube in short order. Refer to Bill Orr's comments[1] for a discussion of a representative air-cooling system for the 8877 tube.

Note the air duct in the photo that directs the air out of the top of the cabinet. The air flow is ducted to avoid the blower from short circuiting the hot air into the blower intake. The air duct is made from a 1/8-inch (3-mm) Neoprene sheet. The Neoprene sheet was first wrapped around the tube and held in place with a large cable tie. The seam was then stitched with a large needle and thread. I made a slit at the bottom of the neoprene tube to allow the plate strap to exit. The blower air intake is through the back panel.



8877 socket assembly. The tube socket is a Johnson 248 submounted 1/2 inch (12.7 mm) below the chassis. Grid clips were made from a stiff copper stock and were silver plated. (An Eimac socket assembly, SK-2210, can be purchased directly from Eimac.) The Eimac Technical Data Sheet for the SK-2200 and SK-2210 air system gives detailed mounting information. If only the grid clips are needed, order Eimac part 149-842.

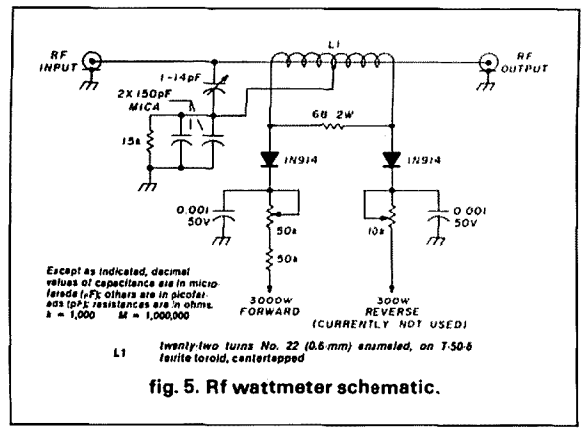


fig. 5. Rf wattmeter schematic.

meters

The meters in this amplifier are 1.5-ampere for plate current and 200 microampere for the multimeter. A microammeter was selected for the multimeter because of sensitivity requirements of the built-in rf wattmeter. The plate-current meter was used as purchased. However, the 200 μA multimeter required work relabeling the scale. The 0-200 μA scale was used for grid current. All other lettering was made with dry transfers available from most electronic suppliers. Note that any labeling that comes on a meter scale can usually be removed with a pencil eraser and a little determination. The additional scale for rf power was added to the meter using a set of dry transfers contained in a kit.*

rf wattmeter

The rf wattmeter (**fig. 5**) is taken directly from the Drake L4B. Any of the popular wattmeter designs will work well. An rf wattmeter was selected over a relative output meter to eliminate the sensitivity control, which must be adjusted at different frequencies.

concluding remarks

Results from using this amplifier have been gratifying. The amplifier loafs at 1 kW dc input. It should give many years of trouble-free service. The project has resulted in a piece of equipment that is of better quality than most commercial amplifiers on the market and can be built at a competitive price.

reference

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2. Irvin M. Hoff, W6FFC, "Pi Network Design for High-Frequency Power Amplifiers," *ham radio*, June, 1978, page 52.

ham radio

*DATAK Corporation, 65 71st Street, Guttenberg, New Jersey 07092.

elliptic lowpass filters for transistor amplifiers

Advances in computer-aided filter design provide increased exactness and number of designs for Amateur use

The typical solid-state rf amplifier usually requires lowpass filtering to attenuate harmonics to an acceptable level. A selection of eleven Chebyshev lowpass filters was recently published for the 160-10-meter Amateur bands, but because of the relatively gradual rise in attenuation, the second harmonic was attenuated only 27-40 dB.[1] For those desiring greater attenuation at the second-harmonic frequency, the elliptic filter may be preferred, because its two resonant circuits can be tuned very closely to the second and third harmonics of the transmitter fundamental output frequency. This technique was first used in 1967 in the design and construction of a 10-meter harmonic TVI filter.[2]

background

In his March, 1974, *ham radio* article, G. Kent Shubert, WAØJYK, improved on the harmonic filtering application and presented six elliptic designs of seven elements, which required only standard-value capacitors.[3] Shubert designed one filter for each band using the well-known and frequently referenced elliptic tables of Saal and Zverev.[4,5] Because the normalized filter design data in these references was available only for the commonly published eleven values of reflection coefficient, Shubert was restricted in his design selections. To minimize the effect of this restriction, the exactness of the designs was compromised slightly to make all the capacitor values come out as standard values, thus simplifying filter construction.

Recently it has become possible to calculate the component values of elliptic filters for *any* desired reflection coefficient using a small computer such as the Radio Shack TRS-80.[6] Thus it's no longer necessary to restrict the elliptic designs to only the published normalized data. Because of this advancement in computer programming, it's now possible to make

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significant improvements on Shubert's designs. This article demonstrates how these advancements in computer-aided filter design can be used to increase both the exactness and number of elliptic lowpass filter designs for Amateur Radio applications.

filter designs

Table 1 lists thirty-one 50-ohm elliptic lowpass filter designs that have the unusual feature in which the three shunt capacitors (C1, C3 and C5) are all of the standard 5 per cent value. These designs were especially selected for transmitter output filtering in the six Amateur radio-frequency bands of 160 through 10 meters. Only those designs having reflection coefficients less than 13 per cent (VSWR = 1.3 and $A_p = 0.074$ *dB*) were selected to minimize the maximum VSWR and to make the designs less sensitive to component-value variation. **Fig. 1** shows the filter schematic diagram; **fig. 2** shows the attenuation response.

The first four columns of **table 1** list the filter design identification number and the frequencies (in MHz) at the A_p, *3-dB* and A_s attenuation levels. The significance of the frequency/attenuation parameters is illustrated in **fig. 2**. Column five lists the minimum value of the stopband attenuation, A_s, in dB. The remaining columns list the reflection coefficient, component values, and the *F2* and *F4* frequencies of maximum attenuation. The column headings of the capacitor and inductor listings are associated with the similarly labeled components in **fig. 1**.

In Shubert's designs, the values of C2 and C4 (capacitors that resonate the inductors to *F2* and *F4*) were given standard values. In **table 1**, however, the values of C2 and C4 are listed exactly as calculated and no attempt has been made to force these two values to be standard.

Standard values for these two capacitors are unnecessary, because these two circuits should be individually tuned to the exact design frequency either by using trimmer capacitors or by slightly varying the inductor turns. For convenience in construction, the standard value closest to the listed C2 and C4 capacitor values may be used if the inductor is adjusted to tune the circuit to the listed frequency. If this is done, the resulting attenuation will differ only slightly from the exact design value.

For example, in filter design 4, if the nonstandard C4 value (375 pF) is replaced by either standard values of 360 pF or 390 pF, and if L4 is adjusted to resonate at 4.04 MHz, the new attenuation response between 2-4 MHz will differ by only ±0.5 dB, respectively from the exact design response.

A similar procedure may be used for C2 and L2. This characteristic of the elliptic filter demonstrates the importance of *accurately* tuning the resonant circuits to the listed frequencies. In comparison, the exact values of C and L of the resonant circuit are less important. This tuning may be made with a calibrated grid-dip meter.

computer-calculated designs

The computer-calculated filter designs of **table 1** have several advantages over the manually calculated designs.[3] The main advantage in using a computer to perform the design calculations is that several designs can be easily obtained for each band, so that one can choose a design that may be optimum for a particular application; or perhaps some capacitor values will be more convenient to obtain than others. The minimum stopband attenuation, A_s, will usually be higher in the computer-designed filters than in those manually calculated. For example, five of Shubert's designs[3] have A_s values of 41 dB or less. In comparison, the computer-designed filters have A_s values between 47-63 dB. The computer-designed filters have a maximum passband ripple amplitude, A_p, of 0.074 dB, which corresponds to a maximum VSWR of 1.3. In comparison, all of Shubert's designs had A_p values of 0.1 dB or more, implying higher VSWRs.

To demonstrate the application of the tabulated data in constructing an actual filter, design 18 was assembled and its insertion loss was measured with a spectrum analyzer. **Fig. 3** shows the assembled filter with the inductor specifications. A plot of the insertion loss is shown in **fig. 4**.

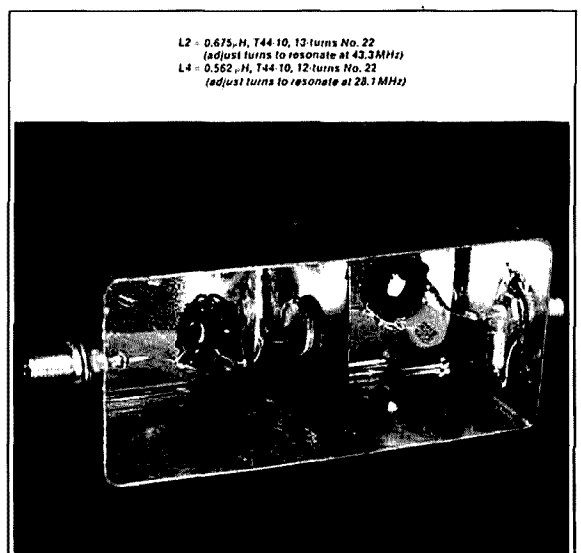


fig. 3. Photograph and inductor specifications of filter constructed from design 18 (F_{A_p} = 14.9 MHz).

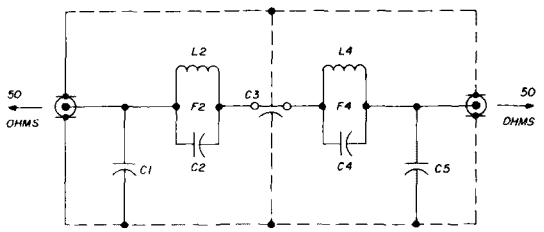


fig. 1. Filter schematic diagram.

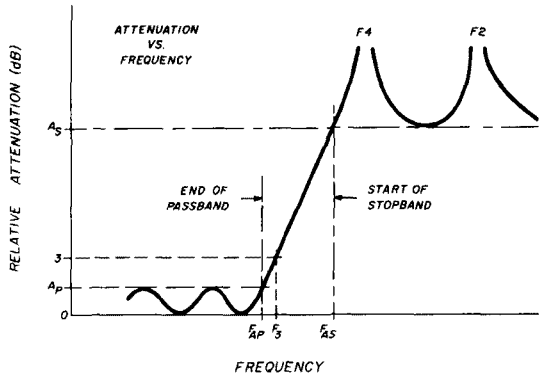


fig. 2. Typical attenuation response.

table 1. Elliptic lowpass filters selected for Amateur transmitter output filtering, 160 through 10 meters.

FLT NO.	F-AP (MHZ)	F-3DB (MHZ)	F-AS (MHZ)	AS (DB)	R.C. (%)	C1 (PF)	C3 (PF)	C5 (PF)	C2 (PF)	L2 (UH)	F2 (MHZ)	C4 (PF)	L4 (UH)	F4 (MHZ)
1	1.87	2.47	5.31	62.4	3.32	1100	2400	1000	63.0	5.15	8.84	173	4.74	5.56
2	1.89	2.19	3.68	53.3	9.50	1500	2700	1300	132	5.39	5.96	369	4.65	3.84
3	1.92	2.35	3.80	49.3	5.41	1200	2400	1000	130	5.10	6.17	372	4.32	3.97
4	2.05	2.40	3.87	50.5	8.22	1300	2400	1100	133	4.90	6.24	375	4.15	4.04
5	2.09	2.55	4.07	48.6	5.39	1100	2200	910	124	4.68	6.60	355	3.94	4.25
6	2.21	2.73	5.62	61.9	5.69	1100	2200	1000	63.8	4.59	9.30	175	4.19	5.88
7	3.90	4.41	6.63	47.6	10.82	750	1300	620	88.4	2.57	10.6	252	2.10	6.91
8	3.91	4.67	7.29	47.8	6.38	620	1200	510	72.6	2.53	11.8	208	2.10	7.61
9	4.15	5.01	9.89	60.5	6.80	620	1200	560	38.5	2.47	16.3	106	2.23	10.4
10	4.16	4.74	7.14	47.3	9.95	680	1200	560	81.3	2.40	11.4	233	1.97	7.44
11	7.07	8.34	13.2	48.9	7.26	360	680	300	39.7	1.41	21.3	113	1.18	13.8
12	7.30	8.34	15.9	60.9	11.71	430	750	390	26.1	1.43	26.1	71.3	1.28	16.6
13	7.55	8.59	13.5	50.2	10.77	390	680	330	40.4	1.34	21.7	114	1.12	14.1
14	7.58	9.56	19.2	60.1	4.66	300	620	270	19.1	1.31	31.8	52.6	1.19	20.1
15	8.26	9.33	14.2	48.4	11.22	360	620	300	40.7	1.22	22.6	116	1.00	14.8
16	8.28	9.84	19.6	61.7	8.03	330	620	300	19.3	1.25	32.4	52.8	1.14	20.6
17	14.7	17.0	32.0	59.5	9.91	200	360	180	13.0	.707	52.4	35.7	.633	33.5
18	14.9	17.3	27.0	48.8	8.40	180	330	150	20.0	.675	43.3	57.0	.562	28.1
19	15.6	18.2	33.2	57.3	8.91	180	330	160	13.0	.661	54.2	36.0	.585	34.7
20	17.5	19.5	29.2	48.2	12.98	180	300	150	20.6	.572	46.4	58.5	.468	30.4
21	22.1	27.3	56.2	61.9	5.69	110	220	100	6.4	.459	93.0	17.5	.419	58.8
22	22.3	25.9	40.4	48.8	8.40	120	220	100	13.3	.450	65.0	38.0	.375	42.2
23	22.9	27.9	43.9	47.7	5.37	100	200	82	11.8	.426	71.0	33.9	.356	45.8
24	24.5	28.4	43.6	48.0	8.69	110	200	91	12.7	.408	69.9	36.4	.337	45.4
25	26.2	29.2	43.8	48.2	12.98	120	200	100	13.7	.381	69.6	39.0	.312	45.6
26	28.7	37.1	77.9	61.7	3.84	75	160	68	4.4	.342	129	12.1	.313	81.6
27	29.3	35.2	55.9	48.6	6.14	82	160	68	9.2	.337	90.4	26.3	.283	58.3
28	30.7	37.3	59.7	48.5	5.39	75	150	62	8.5	.319	96.7	24.3	.268	62.3
29	31.3	35.6	53.6	47.4	10.12	91	160	75	10.8	.320	85.5	31.0	.262	55.9
30	32.4	40.0	81.3	61.4	5.68	75	150	68	4.5	.313	135	12.2	.285	85.1
31	32.6	37.9	58.5	48.2	8.46	82	150	68	9.4	.307	93.9	26.7	.254	61.0

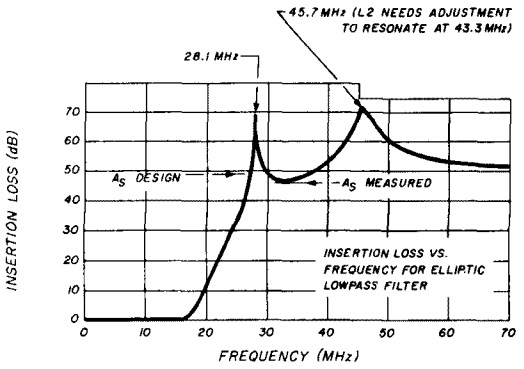


fig. 4. Measured insertion loss of elliptic filter constructed from design 18.

The plotted response shows that the circuit of L4C4 was accurately tuned to the design frequency of 28.1 MHz, but the L2C2 circuit resonance was slightly in error. The effect of this mistuning was not significant (only a 2-dB lower-than-normal level of A_s at 33 MHz), so no attempt was made to adjust the circuit to the correct frequency. This design was intended for a 20-meter filter application, and the attenuation at the second and third harmonics is greater than 50 and 60 dB respectively. The Micrometals T44-10 toroidal cores were on hand, and to expedite construction they were used; if the filter is to be used in filtering transmitter outputs greater than a few watts, however, the larger T80 cores used by Shubert are recommended.

construction notes

The filter was assembled in a 1.578 by 3.5 by 1.547 inch (40 by 89 by 39 mm) Hudson tinned steel box [12] (HU-6570-1.547ST). The center partition and the Button®-mica capacitor ($C = 330\ pF$) are recommended if maximum stopband attenuation is required above 50 MHz. If the filter cutoff frequency is less than about 10 MHz, the center partition probably can be omitted. The capacitor voltage ratings should be 500 V or greater, and the capacitors can be either polystyrene or mica. See references 7, 8, and 9 for information regarding the winding and application of toroidal inductors. References 10 and 11 give two distributors of the Micrometal cores.

Those familiar with modern filter design can confirm the correctness of the designs in table 1 by using one of the published normalized designs of Saal or Zverev to calculate independently the component values of filter design 16. This is possible only because design 16 has a reflection coefficient of 8.03 per cent, which is almost identical with the 8 per cent standard published value. Also, the A_s value for design 16 is 61.7 dB, which is practically identical to the published value of 61.6 dB. Therefore, if the published normalized data for an elliptic design of C0508, $\theta = 25$ (see page 78 of Saal's book) is used, an independent calculation using the $F - A_p$ cutoff frequency of design 16 (8.28 MHz) should give the same component values listed in table 1.

The published normalized values of Saal for C1, C3, and C5 for $A_s = 61.6\ dB$ and for an 8 per cent reflection coefficient are: 0.8574 F, 1.612 F, and 0.7790 F. Capacitor scaling factor, $C_s = 1/(Rw) = 1/(50 \cdot 2\pi \cdot 8.28 \cdot 10^6) = 384.4 \cdot 10^{-12}$. Calculating the filter component values for C1, 3, and 5: $C1 = C_s(0.8574) = 330\ pF$, $C3 = C_s(1.612) = 620\ pF$, and $C5 = C_s(0.7790) = 300\ pF$.

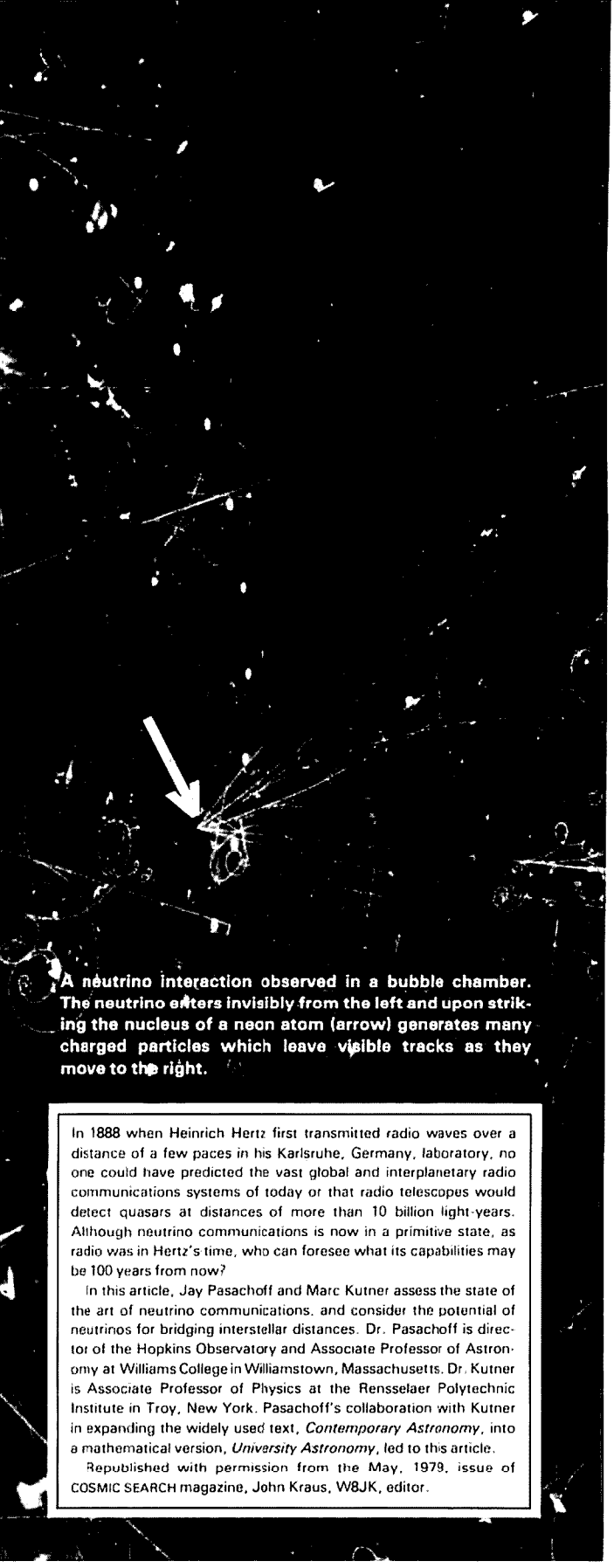
These independently calculated values are identical to the computer-calculated values, and the validity of the computer program used to generate table 1 is therefore confirmed. In a similar way, the other component values of design 16 may be confirmed.

I gratefully acknowledge the assistance of the following: Philip Geffe of Lynch Communications Systems for providing the computer program needed to calculate the elliptic normalized values, Roosevelt Townsend of Honeywell for his assistance in modifying the computer program to generate table 1, Charles Miller of Honeywell for his assistance in plotting the filter insertion loss, and Joseph Gutowski of EWC and Rex Cox of Honeywell for their review of the manuscript.

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12. Hudson Tool & Die Company, Inc., Main Office: 18 Malvern St., Newark, New Jersey 07105.

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A neutrino interaction observed in a bubble chamber. The neutrino enters invisibly from the left and upon striking the nucleus of a neon atom (arrow) generates many charged particles which leave visible tracks as they move to the right.

In 1888 when Heinrich Hertz first transmitted radio waves over a distance of a few paces in his Karlsruhe, Germany, laboratory, no one could have predicted the vast global and interplanetary radio communications systems of today or that radio telescopes would detect quasars at distances of more than 10 billion light-years. Although neutrino communications is now in a primitive state, as radio was in Hertz's time, who can foresee what its capabilities may be 100 years from now?

In this article, Jay Pasachoff and Marc Kutner assess the state of the art of neutrino communications, and consider the potential of neutrinos for bridging interstellar distances. Dr. Pasachoff is director of the Hopkins Observatory and Associate Professor of Astronomy at Williams College in Williamstown, Massachusetts. Dr. Kutner is Associate Professor of Physics at the Rensselaer Polytechnic Institute in Troy, New York. Pasachoff's collaboration with Kutner in expanding the widely used text, *Contemporary Astronomy*, into a mathematical version, *University Astronomy*, led to this article.

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neutrino communications

A discussion of the use of neutrinos for interstellar communications and the search for extraterrestrial intelligence

Though no interstellar communication is going to be quick, it is obviously better to send messages that travel at the highest possible velocity, all other things being equal. This usually leads to the conclusion that we should communicate with radio or other electromagnetic waves, but one nuclear particle — the neutrino — travels at the speed of light, and the possibilities of using neutrinos as the vehicle for interstellar communication should be carefully explored.

It turns out that neutrinos have many advantages for this purpose, along with their major difficulties, and we think that investigation of neutrino communications should not be ignored. We note that we are here exploring possibilities whose realization would be in the distant future; nonetheless, since most other communicating civilizations would be far more advanced than our own, it is an interesting exercise

By Jay M. Pasachoff and Marc L. Kutner

to examine alternative means by which interstellar communication may have evolved.

Though neutrinos are very difficult to detect, the scientific benefits of studying the neutrinos that emanate from stellar interiors or supernovae have made it worthwhile. Continued improvements in the sensitivity of neutrino detection devices can be expected.

advantages of neutrino communications

Much discussion of the Search for Extra-Terrestrial Intelligence (SETI) has been taken up with finding a suitable frequency for radio communications. Interesting arguments have been advanced for a wavelength of 21 centimeters, the water hole, and other wavelengths. It is hard to reason satisfactorily on this subject; only the detection of a signal will tell us whether or not we are right. Neutrino detection schemes, on the other hand, are broadband; that is, the apparatus is sensitive to neutrinos over a wide energy range. The fact that neutrinos pass through the earth would also be an advantage, because detectors would be omnidirectional. Thus, the whole sky can be covered by a single detector. It is perhaps reasonable to search for messages from extraterrestrial civilizations by looking for the neutrinos they are transmitting, and then switch to electromagnetic means for further conversations.

Though the means of detecting neutrinos are now relatively insensitive, we must remember that we are in the dawn of the age of neutrino detection. It is only 23 years since the first antineutrinos were detected; on the other hand it is almost a hundred years since the detection of radio waves, and our sensitivity to them has increased manyfold. We can expect that in the next decades we will be better able to detect neutrinos from space, both those arising naturally from astronomical phenomena and those carrying messages from extraterrestrial civilizations. It may well be that neutrinos are considered by extraterrestrial civilizations to be a more advanced method of communications than radio waves.

Neutrino beams are currently generated on earth by proton beams impinging on targets in large accelerators. Proton beams are highly directional, and neutrino beams are also highly directional. The present neutrino beams generated at the Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois, has a beamwidth as narrow as one-tenth of a degree. The beams are so narrow because of the way they are formed. As the incident proton beams become stronger in energy, the resulting neutrino beams become even more directional.

The doubling in energy expected within two years at Fermilab, to be matched by the accelerator at the European Center for Nuclear Research (CERN), near Geneva, Switzerland, will lead to a neutrino beam about one-twentieth of a degree in width. This is twice as sharp as the beam of the Arecibo radio telescope when used at 21 centimeters. At the distance of the star *Tau Ceti* (12 light years), the neutrino beam will be broad enough* to irradiate all the planets of a system like our solar system. Since we have no idea where any planets might be, we would have to cover roughly this scale to be sure we are not missing planets, not to mention the difficulties in the high precision tracking that would be necessary.



The tunnel that composes the "Main Ring" at Fermilab. The proton beam travels in an evacuated tube (inside square housing) around the 6 kilometer circumference ring 50,000 times per second being constrained to stay in the pipe by over one thousand magnats. On each revolution the beam is given a 3 million electron-volt "kick" from a radio transmitter boosting the proton beam energy to 200 billion electron volts or higher. Pipes carry cooling water to the electromagnet coils located at intervals along the square housing.

neutrinos

In the early 1930s, Wolfgang Pauli suggested that a new nuclear particle might exist to explain the

*Beamwidth 600 astronomical units (AU); the earth's orbit is two AU in diameter and Pluto's is about 80 AU.

apparent lack of conservation of energy and spin in beta decay, a radioactive process that involves the emission of an electron (a beta particle). Soon Enrico Fermi worked out a theory for the new particle, which he called *neutrino*, Italian for "little neutral one (since the particle has no charge and to distinguish it from the neutron, which had recently been discovered). The neutrino is a particle with no charge but with a certain energy and a certain spin; it travels at the speed of light, and to do so, it must have no rest mass.

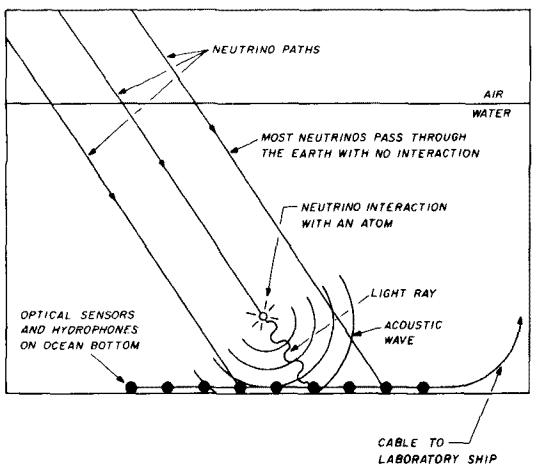


fig. 1. In the Deep Underwater Muon and Neutrino Detection system the light flash and accoustic "ping" resulting from a neutrino interaction with the nucleus of an atom would be picked up by optical sensors and hydrophones (underwater microphones) deployed on the bottom of the ocean.

Neutrinos are the most elusive atomic particles of which we know. They have a very low probability of interacting with any other matter. On the average, in fact, neutrinos can penetate four light years of lead before being stopped. Rather than try to detect individual neutrinos, we normally resort to capturing a tiny fraction of a huge number of neutrinos. In this way, Frederick Reines and Clyde L. Cowan, Jr., detected *anti*neutrinos in 1956 in the flood of particles coming from the Savannah River reactor. The existence of antineutrinos shows that neutrinos too must exist.

The disadvantage that neutrinos interact so weakly with matter is also an advantage, because this property allows neutrinos to escape from the center of a star. The nuclear fusion cycles that fuel our sun lead to the emission of neutrinos of relatively low energy. These neutrinos come straight out of the solar core, reaching the radius of the earth's orbit in 8 minutes, thus providing us with our only direct link to the solar core.

Raymond Davis, Jr., of the Brookhaven National Laboratory, has set up a 400,000-liter tank of perchloroethylene (a type of cleaning fluid, C_2Cl_4) to capture solar neutrinos. His tank is located deep underground in a gold mine at Lead, South Dakota, where it is shielded by earth and rock from other particles that would cause reactions in his material. He is now detecting 1.8 ($\pm$0.4) Solar Neutrino Units (SNUs)* of neutrinos. This amounts to about one interaction every six days.

Davis's results are lower by a factor of almost three than the best current predictions of the solar neutrino outflow, but within about twice the error (standard deviation) in the theoretical predictions, which give 4.7 ($\pm$ 1.4) SNU. Gallium is more sensitive to lower-energy neutrinos than chlorine, and Davis is planning an experiment using gallium; a Soviet group is also planning a gallium experiment.

Still higher-energy neutrinos should be emitted in supernova explosions. Such neutrinos might be detected by an apparatus being considered in Project DUMAND (Deep Underwater Muon and Neutrino Detection). One plan involves setting up acoustic or optical detectors over an area of several square kilometers on the floor of the Pacific Ocean near Hawaii to detect the Cerenkov radiation emitted when neutrinos interact with nucleons in the water. (Cerenkov radiation is emitted when a particle enters a medium traveling faster than the speed of light in that medium and is somewhat analogous to a sonic boom.)

A Very Big Accelerator (VBA) is under discussion as a possible international project on a large scale. This accelerator would generate a proton beam of 10 times higher energy than the new Fermilab and CERN beams. If directed at our solar system from *Tau Ceti*, this beam would encompass the planets out to Neptune.

neutrino generator and detection

Presently the proton beam generated at Fermilab in the 2 kilometer-diameter ring has energies of 400 billion electron volts. Neutrinos are produced in pulses of 10 billion per pulse with pulses occurring every eight seconds. The proton beam impinges on a target, resulting in muons, particles of mass intermediate between electrons and protons. The muons travel in a forward direction and their decay products include neutrinos. This forward beam travels through a "filter" of 1 kilometer of earth, which excludes all

*One SNU corresponds to 10^{-36} captures per chlorine atom per day, or one capture per day among a trillion, trillion, trillion atoms.

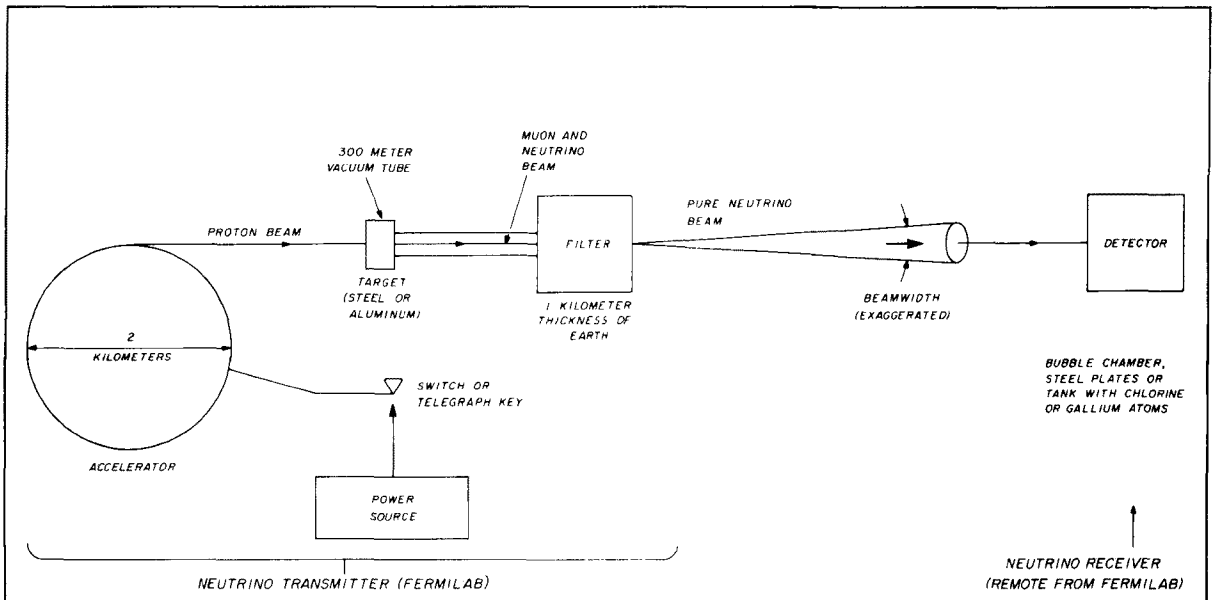


fig. 2. A neutrino "communications system." A guidance system to steer the beam is not shown but probably would employ magnetic deflection of the proton beam.

the particles except neutrinos. To detect the neutrinos, a bubble chamber or an apparatus containing approximately 1000 tons of steel is used. Even that much steel produces only about 1 interaction per pulse. A person can (and often does) stand in the neutrino beam without any effect on either the person or the beam.

As the proton beam is brought to higher energies, the number of protons per pulse goes up proportionally to the energy. Thus the particle flow (or flux) at a given distance from the ring goes up with two factors of energy from the increase in the number of protons and, thus, neutrinos per pulse. This means that the particle flux goes up with the cube of the energy. For a given neutrino beam, the number of interactions in the target is also roughly proportional to the energy. Thus for a one-trillion-electron-volt proton beam, we have calculated that about 50 trillion, trillion kilograms (5×10^{25} kilograms or ten times the mass of the earth) of material would have to be located at the distance of *Tau Ceti* to obtain one interaction per day with a neutrino from earth. This is about the rate of Davis's solar neutrino experiment. We are currently comparing prospective fluxes with the natural neutrino background.

With the technology we expect to have within a few years, we would need ten times the mass of the earth as detector material. However, we must remember that the neutrino pulses are *on* only about 0.00025 per cent of the time. If this percentage can be raised to even one per cent, and the proton beam energy can be brought up by another factor of 10, then the detector mass required is less than one millionth the mass of the earth to detect one neutrino event per day. This is equivalent to a cubic volume of 100 kilometers on a side, not too different from the scale of detectors being proposed for Project DUMAND.

We must also allow for further technological development. Already a detection scheme has been suggested that detects muons simultaneously with the Cerenkov radiation. Detecting muons can be achieved by a smaller apparatus. Even though a large detector mass may be required for interaction, the active part (or electronic equipment) involved could be much smaller.

Some investigation of neutrino communications has been underway for sending a neutrino signal through the earth to nuclear submarines on the other side of the earth, but this will require the reduction of the detection apparatus from a cube 100 kilometers on a side to the size of a submarine.

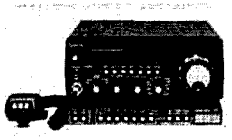
present data

Though solar neutrino schemes involve much lower energies than Project DUMAND methods, solar



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neutrinos represent our longest string of data on interstellar neutrinos. We have examined the Davis records for any sign of obvious messages, and have found none. It seems reasonable that any civilization that chooses to generate strong neutrino beams and point them at a given star would also calculate the appropriate number of neutrinos that inhabitants associated with the star would need to detect the incoming signal. Davis's data involve runs of a month or a few months, with interactions occurring once per day. There is no reason to believe that a neutrino signal need be any shorter in duration than months, nor indeed to be even that short. It seems worthwhile to continue collecting data on a regular basis to have long enough data runs to properly search for an extraterrestrial signal.

conclusions

Current plans for neutrino generation, coupled with prospective abilities for neutrino detection, are beginning to make feasible neutrino messages we might send to be detected at the distances of nearby stars. Though neutrino beams are expensive to generate, this disadvantage may be outweighed by such advantages as very narrow focusing of the transmitted neutrino beam, and the ability to receive simultaneously from the whole sky over a broad range of neutrino energies.

On earth, neutrino communications have lagged radio communications by about 100 years, during which time our ability to send and receive radio signals has increased dramatically. We can hope for similar improvements in neutrino communications in the next decades.

Technologically, the transmission of strong modulated neutrino signals would be a sure sign of an advanced civilization, and we should be looking for such a signal. Since our transmission of a neutrino signal would involve finding a way of making the neutrino beam track the stars to a high degree of accuracy, the transmission of neutrino signals from earth seems farther in the future.

It may be that neutrino communications is best suited for finding another civilization, after which dialogue could be carried out by electromagnetic means. In any case, if our reasoning of the advantages of neutrino communications is correct, then much of the information now crisscrossing the galaxy could be in this mode.

glossary

Muon:
A particle with a mass between that of an electron and a proton. It has a negative charge and a mean lifetime of 2.2×10^{-6} second.
Neutrino:
Either of two massless, electrically neutral, stable particles. One is named "electron's neutrino"; the other "muon's neutrino."

pulse-position control of the CDE Tailtwister rotor

Many Amateurs worry or become frustrated when they put up a large antenna array and then notice how unevenly the system moves when turned by one of the commercially available rotors. Large moments of inertia build up in long-boom hf Yagis or large multi-antenna vhf arrays used in EME communications. These antennas must be rotated at a slower rate than that which most commercial rotors provide. To relieve this frustration, a method is described for incremental pulse-position modulation of a Cornell-Dubilier Tailtwister rotor.

background

I became aware of the large moments of inertia that build up in an antenna system when I began the design of my 160-element collinear array for 144 MHz EME (or moonbounce, as others call it). This array has a 33-foot (10-meter) boom of 3-inch (7.6-cm) OD aluminum tubing that supports four 24-foot (7.3-meter) secondary booms of 1-1/4 inch (3.2 cm) aluminum tubing. Eight Cushcraft DX-120 collinear antennas are mounted on the secondary booms. The antenna array, excluding the elevation mount, weighs about 125 pounds (56.7 kg).

I could picture in my mind (as well as on paper) the jerking and twisting that would occur if this array were rotated by a conventional rotor. I'd planned to use a CDE Tailtwister.

Other complications arise when one wants only to move the array a few degrees in azimuth. A 1-degree change for an array with a 33-foot (10-meter) boom is only about 3.6 inches (9 cm) of arc movement at the end of the boom. The rotor doesn't need to be activated very long to give this change. Also, every time you push a control switch, the rotor tries to turn the array at full speed: quite an acceleration for a long-boom, large-mass array. We must also allow for array coastdown before releasing the brake switch, which complicates matters further.

theory

Could I add speed control to the motor used in the Tailtwister rotor? This question turned out to be easier asked than answered, as the motor is an induction type. It starts to lose torque quickly if its applied voltage is reduced. This problem rules out the use of Variacs and typical triac motor speed controls. After much meditation, I decided to take a different approach. Why not try to pulse-position modulate the rotor motor? I reasoned that if I could pulse the motor with full voltage, I could make it turn only a few revolutions and have practically full torque available. The rotor gearing would reduce these revolutions to a small incremental step in actual rotor position. Two major benefits arise:

1. The small incremental steps can be only parts of a degree, so that positioning the antenna to a particular azimuth setting would be no problem at all.

2. The slow motion of the long boom never allows any appreciable velocity buildup, so no moment-of-inertia problem occurs.

Now all I had to do was develop some hardware to do what all these words are saying, which turned out to be the least difficult part of this project. The pulse-control unit, as I call it, is surprisingly simple. A block diagram of the result is shown in **fig. 1**.

Basically two items were needed. The first was an electronic switch that could be opened and closed for small periods of time to apply power to the rotor motor. The motor would have full voltage applied to it during each pulse. Second, a pulse generator was needed to send constant-width pulses at a variable rate to the electronic switch. By adjusting the pulse width, I could vary the number of revolutions that the motor would turn for a given load, thus varying the incremental movement of the rotor. Also, the pulse rate could be adjusted to vary the number of incremental steps that occurred each second or, in other words, vary the rotor speed.

the circuit

The schematic of the pulse-control unit, integrated with the circuit of a CDE Tailtwister rotor, appears in **fig. 2**. All control-unit parts are numbered starting with X20 so they won't be confused with those that are part of the Tailtwister rotor.

Power supply. Parts CR20, C20, C21, and VR20

By Watson R. Gabriel, Jr., WB4EXW, 5936 Timberwood Trail, Kernersville, North Carolina 27284

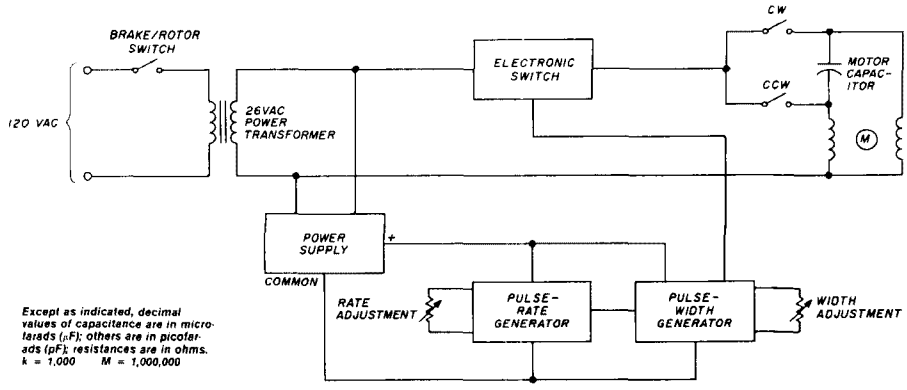


fig. 1. Block diagram of the pulse-control unit added to the Tailtwister motor-control circuit. Brake solenoid and end-of-travel limit switches have been omitted for simplicity.

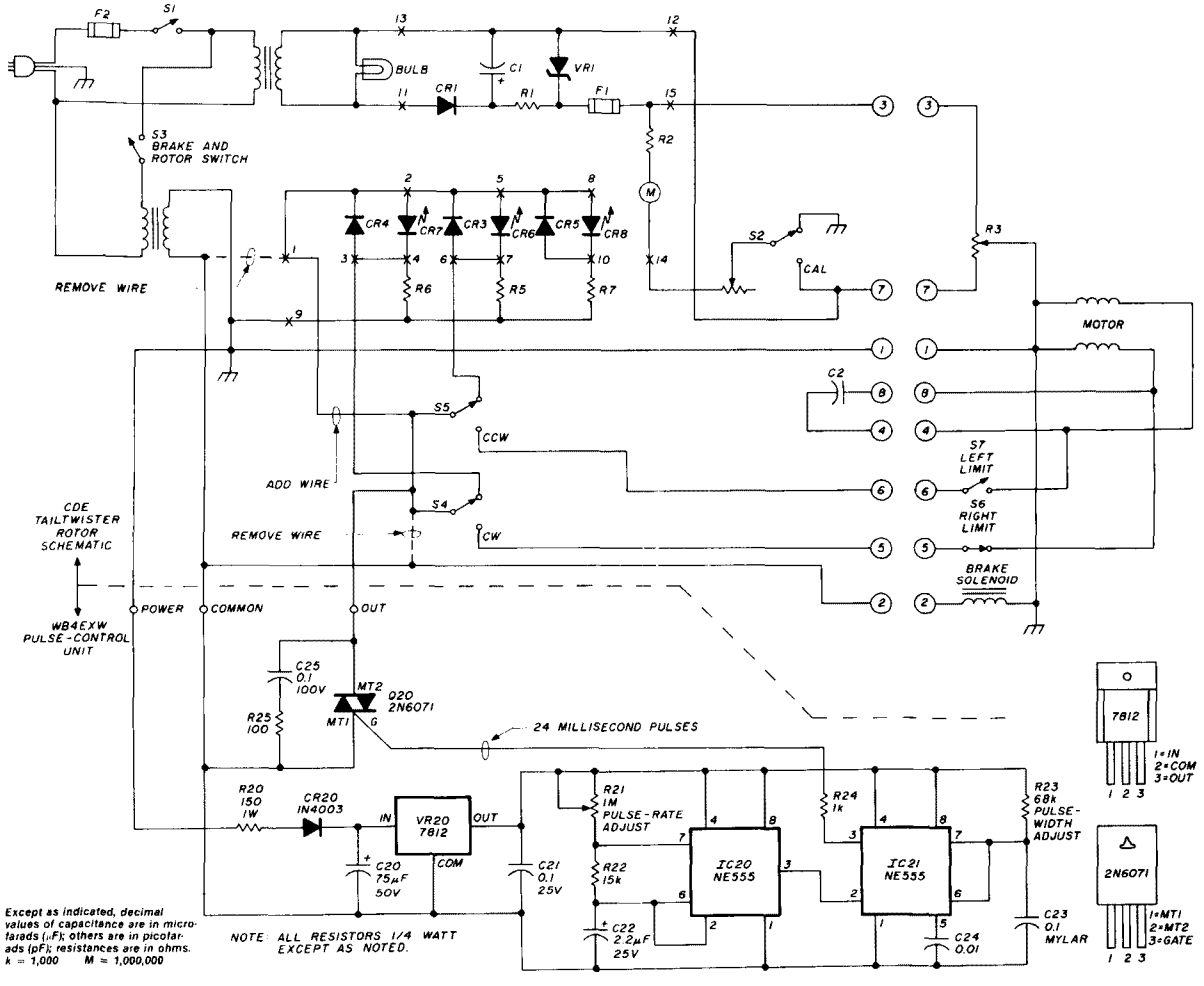
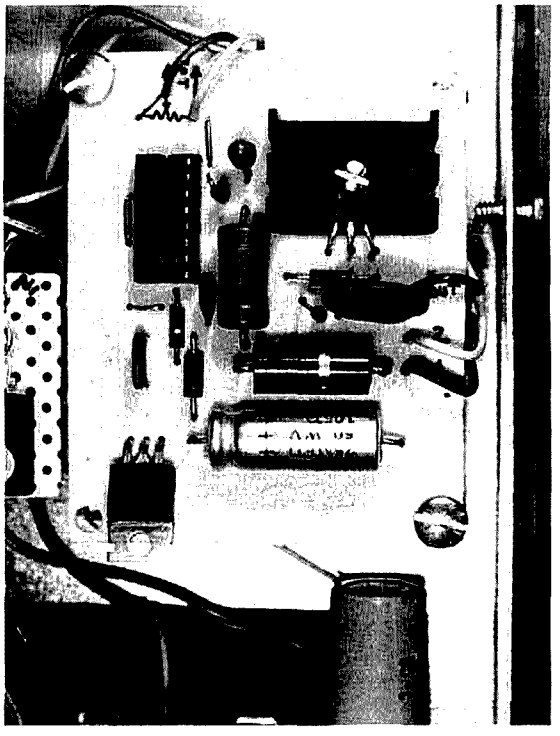


fig. 2. Schematic of the pulse-control unit and Tailtwister control box. The PCU schematic is below the dashed line that separates the two circuits. Note wiring changes to control box.



Close-up of the pulsa-control unit showing parts placement. Unit is mounted on the underside of the Tail-twister control box chassis above the power transformer, as shown. Note that VR20 leans slightly to clear the bottom cover when installed.

define a regulated 12 Vdc power supply for the PCU. Resistor R20 decreases the 26 Vac from the rotor power transformer somewhat, so that the rectified input voltage to VR20 will be below its 35-volt maximum. *Do not* omit R20. You may notice that the ac input leads to the power supply section seem to be hooked up backward. The lead from R20 (PWR) connects to terminal 1 of the eight-terminal output connector of the rotor control box. It is grounded to the chassis. The pulser unit common lead is connected to terminal 2. These power leads *must* be wired in this manner to provide proper phasing to the electronic switch.

Pulse-rate generator. The pulse rate generator is made from IC20, an NE-555 timer wired as an astable multivibrator. Resistors R21, R22, and capacitor C22 determine the frequency of oscillation of IC20. R21 is a 1-meg pot, which can be a panel-mount type for varying the pulse rate. Or it could be a trimpot mounted on the PC wiring board for those who like set-it-and-forget-it controls. The minimum pulse rate was set to about 0.5 Hz.

It's possible to allow IC20 output to provide the control signal to the electronic switch. But if you investigate the inner workings of an NE-555 used in the astable mode, you'll find that the duty cycle also varies as the frequency of oscillation is changed. I wanted constant-width pulses applied to the electronic switch, so that the incremental movement of the rotor could be controlled. Thus, IC21, another NE-555, was added as a monostable multivibrator.

Each time IC20 output (pin 3) goes low, it triggers IC21. IC21 output (pin 3) then goes high and turns on the electronic switch. IC21 pin 3 stays high for a period determined by R23 and C23. The output pulse width is determined by:

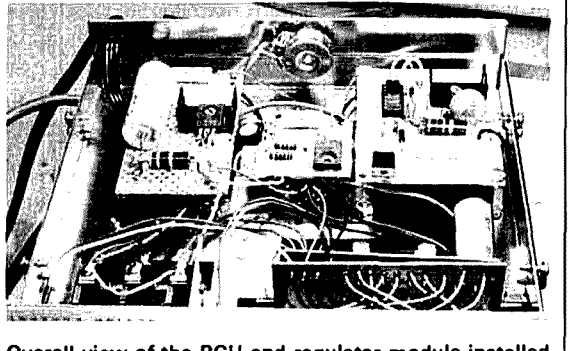
$$T = 1.1\,RC \qquad (1)$$

where T = Output pulse width (seconds)
R = R23 resistance (ohms)
C = C23 capacitance (farads)

Realize that the tolerances of C23 and R23 may make **eq. 1** seem invalid; actually, the formula is quite accurate.

Pulse-width calculations. The pulse width in my unit is about 24 milliseconds. The 0.1-μF cap I used for C23 supposedly had a tolerance of $\pm$10 per cent. Using **eq. 1**, I should be using a 200k resistor for R23. However, I ended up with a 68k to obtain the 24-millisecond pulse width. (The capacitor was way out of tolerance or incorrectly labeled.) Rough measurements indicate that this pulse width gives an incremental rotor travel of about 0.1 degree for my antenna system. By varying the R23 value, you can change the pulse width to suit your needs.

Electronic switch. The last part of the pulse control



Overall view of the PCU and regulator module installed in the control box. The smaller board next to the PCU is the regulator module. Also shown is the external rate-adjustment pot mounted on the rear panel. Azimuth-indicating meter in this control box has been modified to a digital readout for improved accuracy.

unit to be described is the electronic switch. A triac, Q20, gave simple, full-wave ac control to the rotor motor. Output pin 3 of IC21 going high will turn on the triac. The triac will pass current to the motor so long as it has gate drive. When gate drive is removed, the triac will turn off the next time that the ac current through it passes through zero. The suppression network, made up of R25 and C25, which is across the main terminals of the triac, was added to prevent triac false triggering. In some cases, where a triac is used to control an inductive load, there's enough phase difference between the voltage and current waveforms to cause the triac to retrigger when the gate drive is removed. Later I found that the suppression network was not needed in this application, but I left it in the circuit as a precaution.

I also found that I didn't need additional circuitry to make the triac switch at the zero points of the ac voltage waveform. No radio frequency interference has been noted.

printed wiring board

A full-size layout of a printed wiring board for the pulse control unit is shown in fig. 3. It's designed to mount on two 8-32 by 1/2-inch (M4 by 12.5 mm) threaded spacers that are screwed down onto the existing mounting bolts for the power transformer in the Tailtwister control box (see photo). Solder pads are provided for external connections. Don't forget to install the three jumpers on the printed wiring board.

The two NE-555 timers mount in one 16-pin IC socket. Both are oriented in the same direction as shown in the parts layout (fig.4). The heatsink used for the triac is a Thermalloy 6107B. A similar heatsink can be made from a piece of scrap aluminum. If a substitute is made for the 2N6071 triac, be sure that it has the same pinout and triggering characteristics.

Notice that the voltage regulator must be tilted somewhat to clear the bottom cover of the rotor control box. It does not require a heatsink. Resistors R22 and R25 mount vertically. C22 is a small dipped tantalum capacitor, and C23 should be a Mylar capacitor for stability.

The pulse-rate generator control pot can be a printed wiring board type such as a CTS X201 or can be a panel-mount pot as shown in the photo. If an external pot is used, wire it so that clockwise rotation of the shaft decreases the total resistance. Then the pulse frequency and rotor speed will increase with clockwise rotation.

installation

Only five wires must be soldered to the printed wiring board (three if you mount R21 on the board) for

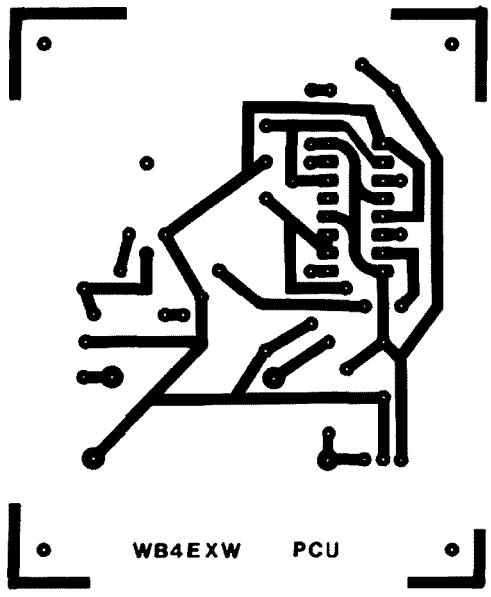


fig. 3. Full-size printed wiring board layout for the pulse-control unit. Wire side is shown.

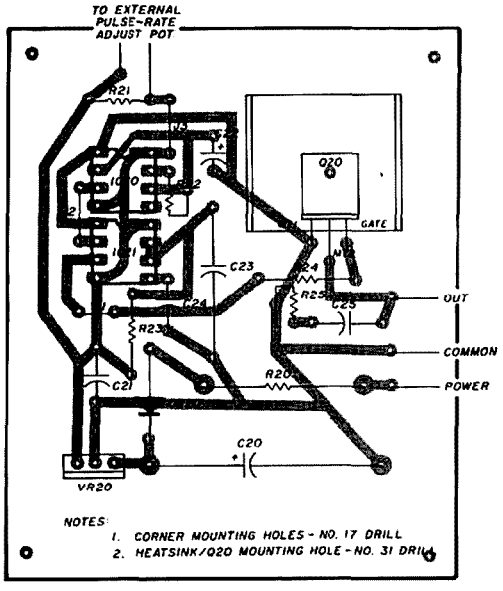


fig. 4. Parts placement for the pulse-control unit. IC20 and IC21 mount in a single 16-pin dual inline socket. R22 and R25 mount vertically. Do not omit the three jumpers (labeled J1, J2, J3). A trimpot can be used for R21, or leads can be extended to a panel-mounted pot.

external connections. Solder two wires, preferably color-coded, to the pads marked PWR and COM. Make sure the wires are long enough to reach to the rotor control box eight-terminal connector block. Solder another wire, that will reach to the CW and CCW control switches, to the pad marked OUT. The last two wires are for the external pulse-rate adjust pot; their length depends on where the pot is mounted.

Before permanently mounting the pulse-control unit, you must make two minor wiring changes in the Tailtwister control box. You must first remove the existing wire that connects terminal 2 of the eight-terminal connector block to the common terminals of the CW (S4) and CCW (S5) control switches. Leave the jumper that connects the common terminals of S4 and S5 together in place.

Next unsolder the wire from terminal 2 of the connector whose opposite end is soldered to point 1 of the Meter/LED printed wiring board. Connect the end of this wire that was on terminal 2 to the common terminal of either S4 or S5. This wiring change avoids a triac gating problem due to the LED indicator circuitry. The LEDs will still be functional but in a slightly different manner, as discussed later.

Mount the printed wiring board on its spacers over the power transformer. Solder the PWR wire to terminal 1 and the COM wire to terminal 2 of the eight-terminal block. Connect the OUT wire to the common terminal of either the S4 or S5 control switch. The last two wires connect to the pulse-rate adjust potentiometer. This completes the hookup of the unit.

checkout

Check all wiring against **fig. 2** and the instructions in the previous section to uncover any possible wiring errors. Next, set the rotor-control box on its side so you have access to both pulse-control unit and eight-terminal connector. Set the pulse-rate adjust pot to mid position.

Turn on the control-box power switch. This should cause the meter to indicate existing rotor position and become illuminated. Connect the common probe of an ac voltmeter to *terminal* 1 of the eight-terminal connector, and connect the input probe to terminal 2. Press the BRAKE RELEASE switch on the control box. This should cause the brake to release; about 26 Vac will be indicated on the voltmeter. The green LED that normally indicates brake release should light, but it should flash on and off. (It will flash at the pulse rate set by R21.) The brake solenoid now is receiving full power, but the LED flashes so you can set the desired pulse rate before applying pulsed power to the rotor motor. Vary the pulse rate adjust pot to see that the LED flashes from about 0.5 Hz to full on. If this checks out, proceed to the next step.

Leave the common voltmeter probe connected to terminal 1 and connect the input probe to terminal 6. Press the BRAKE RELEASE switch, then press the CCW control switch. Pulsed 26-Vac should show on the meter (the voltmeter will not actually indicate 26 Vac because of the short pulses). Both green brake and red CCW LED indicators should flash with the 26-Vac pulses. Your antenna should rotate counterclockwise at a much slower rate than before.

Next, remove the probe from terminal 6 and connect it to terminal 5. Press the BRAKE RELEASE switch again, then press the CW control switch. Pulsed 26-Vac should show on the voltmeter; the brake and CW LEDs should flash, and your antenna should slowly rotate clockwise.

If you have problems, recheck all wiring and use the schematic and circuit-board description as a troubleshooting guide. When checking the operation of the pulse-control unit, be sure to use terminal 2 and the *common point* for voltage measurements. Also note that the pulse-control unit receives no power unless the BRAKE RELEASE switch is operated.

This modification is made to a CDE Tailtwister rotor, but is also applicable to HAM-type rotors. In fact, I initially checked out the pulse-control unit in my HAM-2 rotor. All wiring changes in the rotor-control box are the same except for the LED indicator wire change. Since a HAM-2 or -3 has no LED indicators, this change doesn't *have to be made.*

position circuit modification

You've probably noticed the small circuit board mounted next to the pulse-control unit (photo). It is a 13-Vdc regulator module that replaces the zener diode and current-limit resistor on the Tailtwister printed wiring board. This circuit offers a more stable regulated source for the azimuth indication circuitry. The schematic (**fig. 5**) uses a simple 8-volt, 3-terminal regulator. The 500-ohm trimpot allows the output to be adjusted to 13 volts. The filtered dc supply is about 30 volts and is close to the maximum input voltage rating of the 7808 regulator, so a 150-ohm, 1/2-watt resistor was added to reduce the regulator input voltage. An added benefit is reduced power dissipation. Mine was built on a small piece of perf board, mounted on a standoff in an existing hole in the control-box chassis.

To wire the regulator module, first remove R1, the 390-ohm, 2-watt resistor, and VR1, the 13-volt zener from the rotor printed wiring board. Don't use much heat, as the traces on the printed wiring board are fragile. Next, connect the module IN terminal to the pad left by R1 that connects to the positive lead of C1. Connect the OUT terminal to the pad left by R1

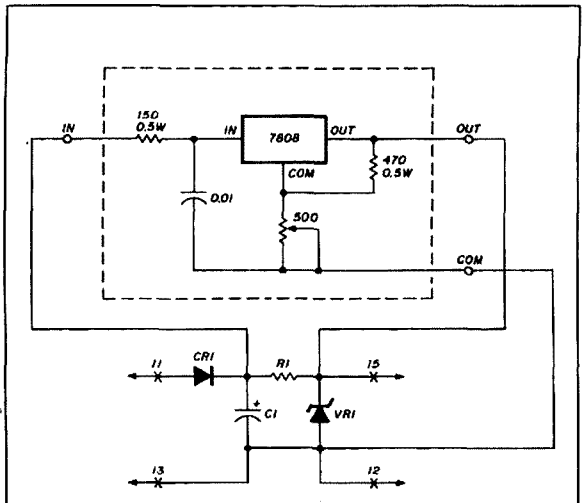


fig. 5. Schematic of the 13-volt regulator module for the rotor position is contained in the dashed box. Also shown are the connections from the module to the original circuit. R1 and VR1 are removed before connections are made. Adjust the trimpot for 13 Vdc across terminals 3 and 7 of the control box.

that connected to VR1 cathode. Solder the COM terminal to the pad that previously contained the VR1 anode lead. Turn the control box on, and adjust the trimpot for 13 volts across terminals 3 and 7 of the connector block.

conclusion

This modification to the Tailtwister rotor system has made controlling my large EME array a dream. Variable speed control, from 360 degrees per minute down to much less than one degree per second, allows turning torque and positioning overshoot to be minimized. The system would now lend itself well to microprocessor control; thus, this modification should also be of interest to Amateur satellite users.

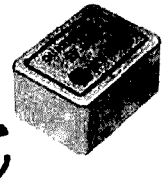
My rotor-control box has also been incorporated into a digital readout similar to that described by K1DG.[1] Positioning accuracy has been increased, as errors of 5 degrees or more existed in the indication circuitry alone in my control box before the digital indicator was added. Now my position accuracy seems to be limited mainly by a) the potentiometer linearity, and b) the accuracy to which I can set the antenna to a calibrated point.

reference

1. Doug Grant, K1DG, "Digital Readout for the HAM-3 Rotator, *ham radio*, January, 1979, pages 56-59.

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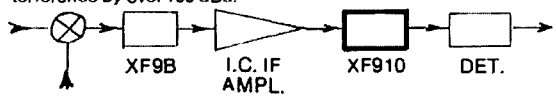


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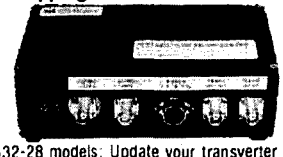
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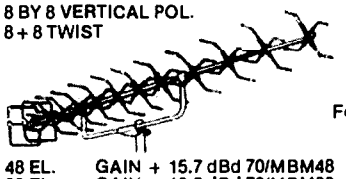


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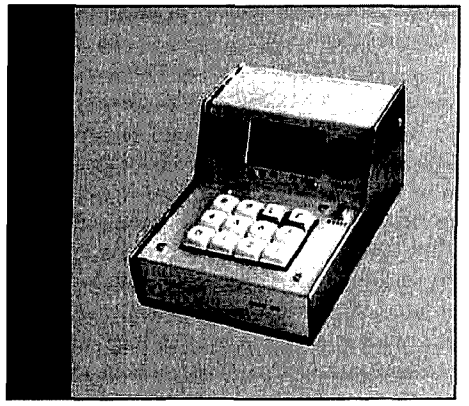
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microcomputer-based contest keyer

During the last CW contest, did you wish you had a memory keyer to send the contest exchange and give you more time for log and dupe-sheet entry? Did you wish you could automatically transmit the proper QSO number and generate any contest exchange? The microcomputer-based contest keyer may be the answer. This fully iambic keyer has ten programmable messages, a four-digit QSO counter, and the flexibility to transmit almost any contest exchange. An added feature is the display of the current code speed setting.

Several years ago I used tape-recorded tones to drive a relay and key my transmitter during a CW sweepstakes. Since this first attempt at automation, I built several memory keyers,[1] a TTL CW QSO number generator, and an 8080 microprocessor keyer that required three circuit boards. Because of the decreasing cost of microcomputer chips, I thought the time had arrived to design a state-of-the-art contest keyer.

Several operational objectives were set for the design. First, it should be an iambic keyer having dot and dash memory plus the optional forced-letter space of the popular WB4VVF *Accu-Keyer.*[2] For simple programming, the user should be able to load messages directly in code from the keyer paddle. Next, there should be several options such as automatic QSO number and RST generation. Last and most important, the keyer should be simple and natural to use but be flexible enough for any contest exchange. The result is the microcomputer keyer presented here.

circuit description

Keyer construction is shown in the lead photo and **fig. 1.** Instead of a large keyboard, I selected a simple, twelve-button keypad for control. A potentiometer is included to adjust code speed and a four-digit LED display is included for QSO number and other alpha-numeric keyer messages. Simplicity results from using an Intel 8748 programmable microcomputer. The advantage of such a device is the ability to perform complex tasks with minimum circuitry. Software may be reprogrammed for other features or options. The following sections describe the design, discuss operation, and outline software routines for the keyer functions.

The keyer circuit, **fig. 2,** requires only seven integrated circuits and six transistors. The 8748 microcomputer, U1, contains 1024 bytes of electrically programmable read-only memory (EPROM), 64 bytes of random access memory (RAM), a programmable counter, and three 8-bit input/output ports. Since a complete description of the 8748 was recently published, it will not be repeated here. Readers should review the article by N6TY[3] and the Intel *MCS-48 Microcomputer Users Manual.*[4]

The 8748 has limited RAM for this design. U2, an Intel 8155, is used to expand the message buffer area. The 8155 contains 256 bytes of RAM, three input/output ports, and a 14-bit counter; only the RAM section is used. While this may seem a waste of internal functions, the 8155 will directly interface with the 8748's multiplexed data and address lines, DB0 to DB7. Additional interface circuitry is not required, saving at least two additional chips and considerable wiring.

U3 is an Intel 8279 programmable keyboard/display interface.* This versatile device can drive up to thirty-two multiplexed 4-bit display digits and simultaneously decode a 64-button keyboard. This design uses the interface to drive four 7-segment LED displays for alpha-numeric messages to the user. It also scans the 12-button keypad, decoding the key and signalling U1's IRQ (Interrupt Request) input with a logic 1. An internal first-in, first-out (FIFO) buffer stores up to eight keypresses; the user can "type ahead" without losing inputs.

Display multiplexing of the common-anode 7-segment display reduces the number of interconnect wires from 32 to 11. Anodes are switched by Q3 to Q6 from U6 inverting SL0 to SL3 from U3. Scan out-

*U2, U3 *functions* are programmed by commands from U1; the EPROM within U1 contains the actual program for the entire keyer.

By Andrew B. White, K9CW, 31 Quebec Road, Marlboro, New Jersey 07746

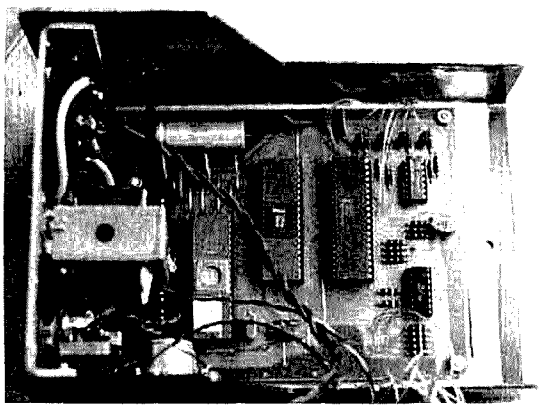


fig. 1. The keyer electronics are contained on one single-sided printed circuit board.

puts SL0 to SL3 are also used for the switch rows in the keypad. Segment driving is accomplished by A0 to A2, B0 to B3 from U3 through U7. Scanning is invisible to the user.

Keypad switch columns are connected to RL0, RL2, RL4, and RL6 of U3 for key decoding. U3 provides debouncing and key rollover detection internally. The keypad may be a conventional telephone type with separate switch contacts.

command and control

U1, U2, and U3 are all connected to the same 8-bit data/address bus, DB0 to DB7, and the same Read (RD) and Write (WR) control lines. Data input or output for the microcomputer will be enabled by a logic 0 on either U1-36 (chip select for U3) or U1-37 (chip select for U2). U1-35 is the Control/Data (C/D) input for U3; Control mode (logic 1) is for display scanning, Data mode (logic 0) reads the keypad and loads the display.

The keyboard/display interface requires a clock input for display multiplexing and other timing operations. This is supplied by U1's Address Latch Enable (ALE) and is equal to the crystal frequency divide by 15. This signal eliminates a separate display oscillator. It should also be noted that U1 contains an internal clock oscillator circuit, requiring only an external crystal.

Dual timer U4 functions as both code-speed oscillator and sidetone generator. The code-speed section, U4A, is enabled by a logic 0 on U1-34. The same enable signal energizes clock indicator CR1 to indicate that the code clock is on. Code speed output, U4-5, is connected to U1's internal 8-bit counter. The microcomputer will set the length of one dot as 100 code speed pulses during CW operations. U4A oscillates at 100 times dot rate and is set by R1; speed range may be altered from the keypad.

Transmitter keying occurs when U1-33 is logic 0 (U5-10 at logic 1). The Q1, Q2 circuit is used with grid-block keying on my transmitter. Key-up voltage at the TX line is about −30 Vdc. Key-down voltage is close to ground. Other keying methods will require changing the Q1, Q2 circuit.

The microcomputer interrogates the key dot and dash paddle switches through I/O ports at U1-27 and U1-28. Internal pull-up resistors allow direct key connection.

U1 will automatically reset to program start when turned on. A manual reset push button, S1, is included for convenience. CR3 and CR4 are program status indicators and are described later.

Sidetone oscillator U4B is optional. The speaker may be any small unit with 8-ohm impedance or higher. CR2 indicates key down and should be retained; a keyer option function allows holding key down for tuning.

software routines

Microcomputer hardware is useless without a program to make it "come alive". Software routines are described, but the detailed program is too long to include here. A complete program listing is available from the author.†

A flowchart of the main software polling loop appears in fig. 3. At power on or RESET, the keyer status flags are initialized and -HI- appears on the 4-digit display. The program enters a loop that continually checks the key paddle switches and keypad switch status, waiting for some request. Any switch closure will enable a branch to a routine that will generate the proper message or code element.

For example, assume the dot paddle switch is closed. The microcomputer turns on the transmitter for one dot period. It also checks the dash paddle switch and sets the dash memory flag if the dash switch was closed before the dot was completed. If so, a dash will begin after the dot space. Holding either dot or dash paddle closed will generate successive dots or dashes with proper spacing.

If no key paddle switches are closed, the microcomputer checks the letter space option. If enabled, no paddle inputs are processed for two dot periods, corresponding to one letter space interval. Key paddles are still tested during this interval. If either is closed during the interval, the proper flag is set and the appropriate dot or dash is sent after interval com-

†A copy may be obtained from the author for $3.00, which covers reproduction and postage costs.

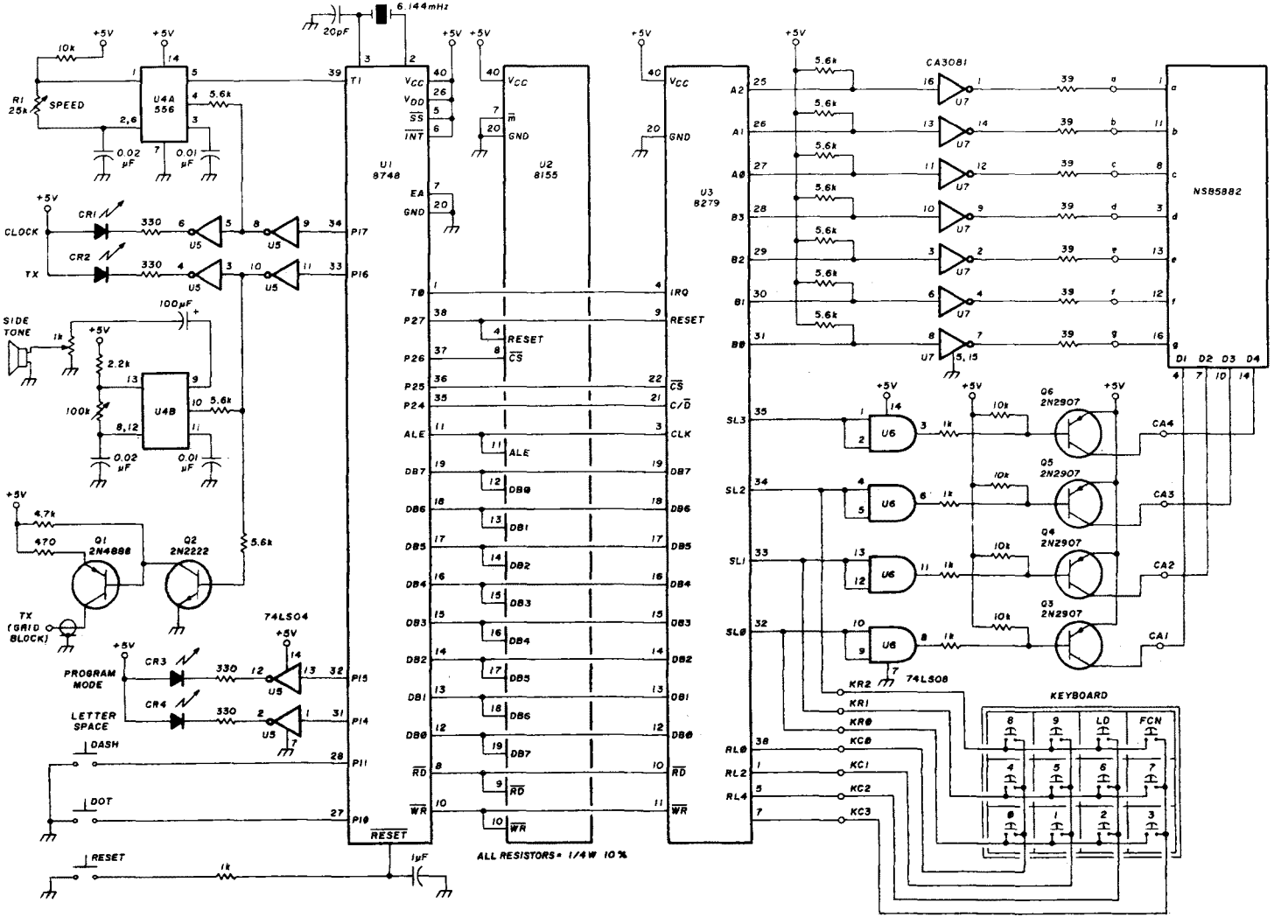


fig. 2. The keyer schematic. The four-digit LED display module may be replaced with four individual seven-segment common-anode digits.

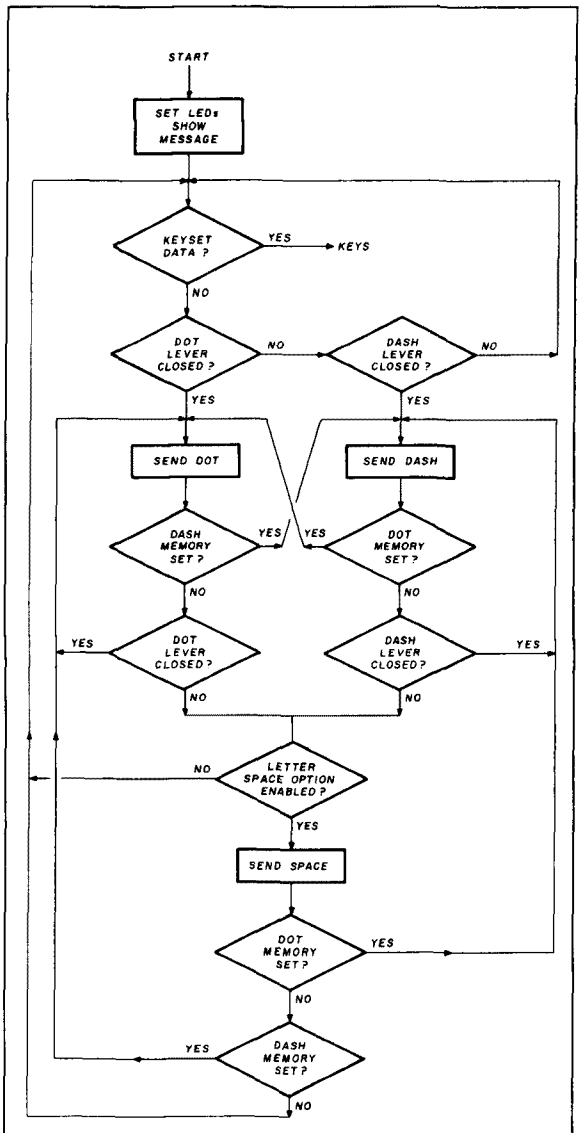


fig. 3. A flow chart for the microcomputer keyer program. The keyer is fully iambic and has an optional forced letter space.

pletion.* If no requests are pending, the program returns to the main polling loop and waits for the next input.

Pressing one of the keyboard switches calls a keypad processing routine. This routine decodes the keypad and executes one of several routines shown in the flow chart of **fig. 4**.

function keys

To set various keyer options, the keypad F (FUNCTION) key is pressed, followed by 0 through 9 for the selected option. Pressing F will display -F- with the third digit blank to indicate an option number must be entered next. Entering the option will fill in the display and execute the function.

Table 1 summarizes function-key options. The first four, F-0 through F-3, will display, increment, decrement, or load a four-digit QSO counter. If QSO count load is selected, the number keys are used to enter an initial count. Once this initial count is entered, pressing the F or L (load) key will load it into memory as the current QSO count.

table 1. Function key options are activated by first entering F on the keypad, then the option number. Function F-9 may be terminated by pressing any key or key lever.

keypad entry	description
F-0	display QSO total
F-1	increment and display QSO total
F-2	decrement and display QSO total
F-3	load the QSO total
F-4	toggle forced letter space option
F-5	toggle 3-digit QSO number option
F-6	toggle -HI-/QSO-total display option
F-7	display code speed in wpm
F-8	toggle code speed range
F-9	tune transmitter (key-down hold)

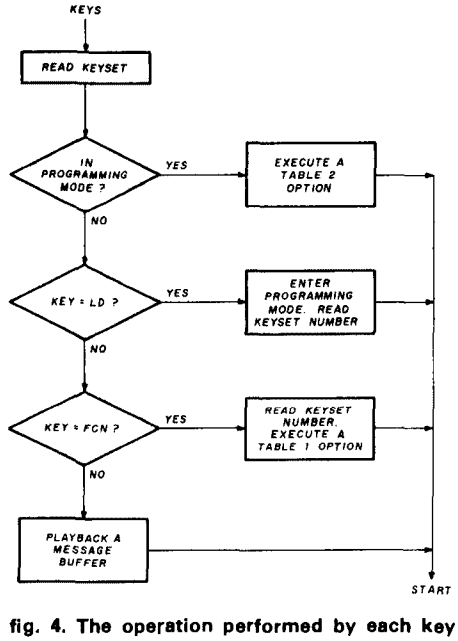


fig. 4. The operation performed by each key depends on the current keyer mode. For example in the message programming mode, the table 2 options are selected.

*The microcomputer is able to do several things seemingly at once due to execution speed and internal IC circuitry.

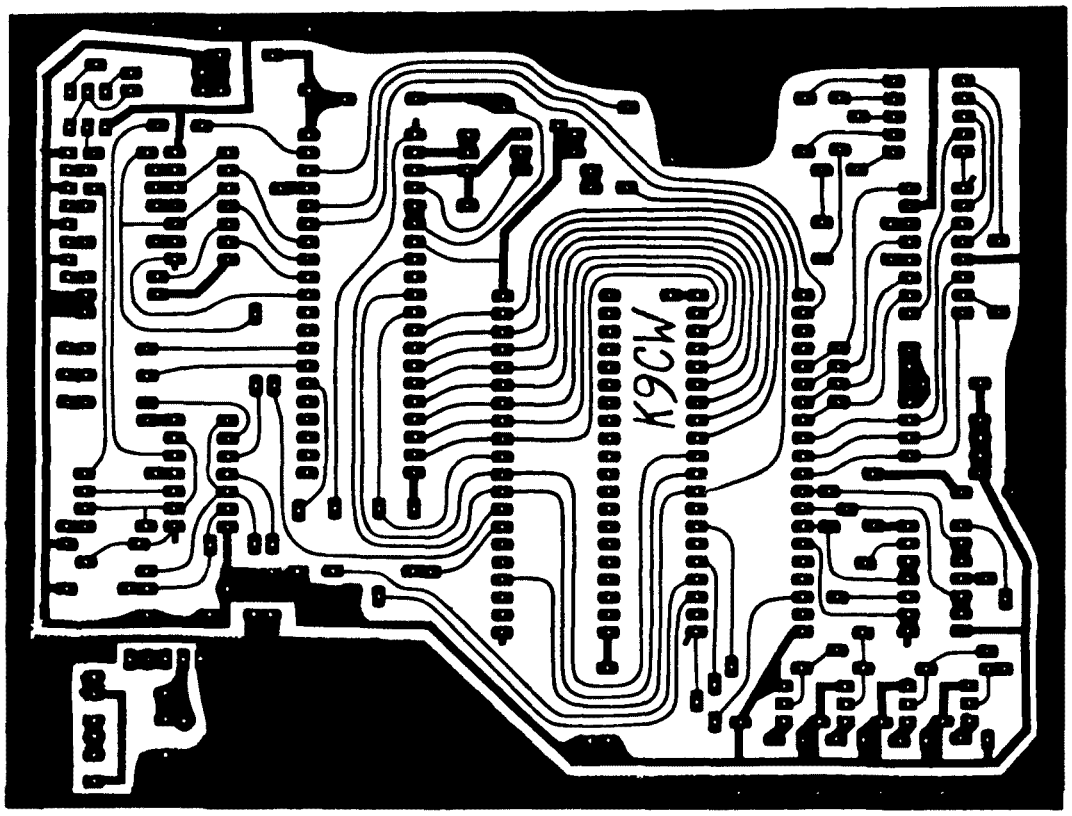


fig. 5. Printed circuit board pattern for the keyer shown from the foil side.

Options F-4, F-5, and F-6 select various keyer operating modes. Letter space option F-4 will force a letter space if neither dot nor dash is closed upon completion of a code element. Front panel indicator CR4 will light if this function is enabled. Option F-5 determines if QSO numbers should always be transmitted as three digits or if the leading zeros in the number should be suppressed. Option F-6 allows display of QSO total instead of -HI- during the input waiting period. Default values at turn-on are: Letter space enabled, suppress leading zeros, display -HI-.

Current code speed in words per minute is displayed by the F-7 option. Since the microcomputer is continuously measuring speed, speed control R1 can be adjusted through digital readout. Pressing any key or paddle lever will exit this function.

Option F-8 selects speed range, either 16-60 wpm or 5-30 wpm. Default value is 16-60 wpm. Option F-9 will key down the transmitter for tuning purposes; key up occurs on pressing any key or the paddle. Transmit indicator CR2 will be on and -F9- displayed during key down.

loading messages

To load one of the message buffers, the L key is pressed, followed by a selected message number of 0 through 9. Entering only L will display -L- with a blank third digit prompting the user for a message number. Entering the number will fill in the display such as -L5- for message number five.

Once the load identification is complete, the manually sent code is stored in memory until either F or L is pressed to terminate the message. The number of memory bytes per message is displayed during message entry. Message buffers 0 through 9 are contiguous in U2 so that individual messages can be up to 25 bytes long without interfering with the next higher message number.

Twenty-five bytes can store 100 dots, dashes, or spaces, but this is not a limit. Because the keyer allows variable message length, one long message containing over 1000 dots, dashes, or spaces is possible; this is an average of 200 letters at three dots or dashes per letter.

In addition to manually entered code, several special functions can be loaded into a message. Table **2** gives the function options and a specific display for user confirmation. CR3 will be on during message loading.

table 2. Message loading options are activated by a single keypad entry. These options insert special functions into the message during message loading.

keypad	display	description
0	-C0-	send QSO total
1	-C1-	increment and send QSO total
2	-59-	send 5NN or 5 (keypad) 9
3	-IP-	send keypad numbers
4	-SP-	insert a letter space
5 - 8		ignored; reserved future use
9	-00-	restart message loading
L or F		terminate a message load

special message options

During playback, option 0 transmits the current QSO total as two to four numbers depending on leading-zero suppression previously set by F-5. Option 1 first increments the QSO total then sends the number.

Option 2 transmits an RST in one of two formats. If a key has been typed during message playback but before this option is encountered, that keypad number is sent as the middle digit (signal strength) in the RST. If no keypad number has been pressed, 5NN is transmitted.

Option 3 allows transmitting a number directly from the keypad. The keypad FIFO buffer is checked when this option is encountered. If any keypad numbers are stored (maximum of 8), they are sent, the FIFO empties, and message playback resumes.

Option 4 simply inserts one letter space each time it is entered. Option 9 allows the user to restart loading in case of error. Options 5 through 8 are currently ignored, reserved for future additions.

These options allow almost any contest message to be loaded. For example, 599001 can be loaded by typing 2, then 1. Keypad 2 calls for the 5NN; keypad 1 calls for the QSO total (incremented from zero, no suppression of leading zeros). NR 100 IL is loaded by manually keying NR, pressing 1 on the keypad, pressing 4 twice for two letter spaces, then keying IL manually.

During message loading, a routine measures the time between manually keyed dots and dashes. It corrects most spacing errors. No more than one word space interval will be automatically stored in memory. The user can stop loading without filling the memory with spaces. No word space is automatically inserted after loading options. Inserting spaces (option 4) permits storage of perfect Morse code.

message playback for transmission

A stored message is played back by simply pressing the appropriate keypad number. If message number seven is selected, the display shows -P7-. If one of the QSO number options is encountered in a message, the current or incremented QSO count is displayed. The keyer returns to the main polling loop when a message is complete and displays -HI- or the current QSO count (if F-6 is set).

Manually sent code can be inserted at any time during a message playback. When a paddle switch is closed, the keyer stops and waits for a word space interval. If the paddle switch is still closed, manual code transmission begins. When manual code ceases, the stored message playback continues. Message playback can be halted at any time by pressing the RESET button or briefly tapping the dot or dash levers.

A common method of storing Morse code in a digital memory is to use a length equivalent to each element. A Morse dot would appear in memory as binary 010. A Morse dash would be binary 01110. This keyer uses two bits for each element: A letter space is binary 00, a dot is binary 01, a dash is binary 10. Binary 11 is used as an option indicator for one of the message options. This assignment allows four code elements per memory byte.

construction

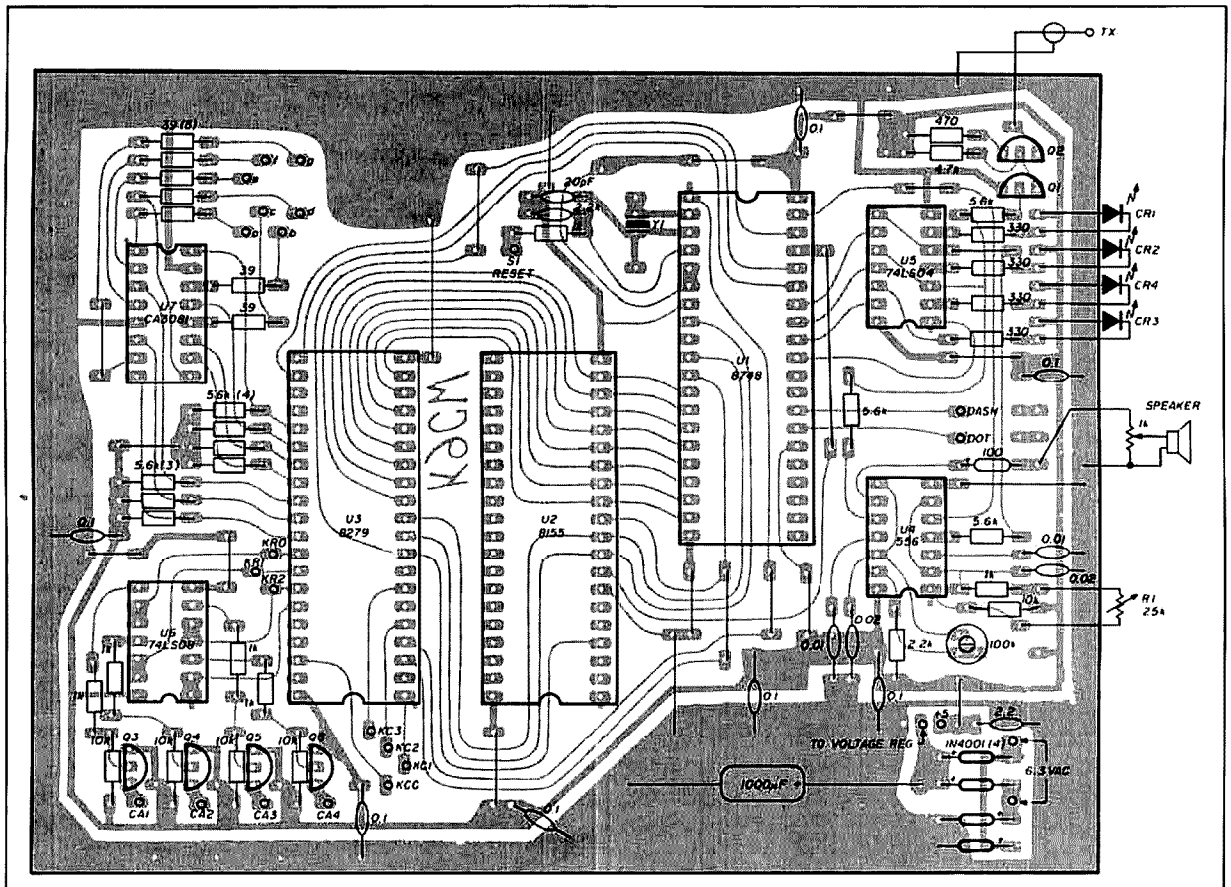
The circuit may be built on the PC pattern of figs. **5** and **6** or with wire-wrap techniques. Sockets are suggested for either case to avoid IC damage. Space has been provided on the PC layout for diode rectifiers and a filter capacitor. A three-terminal voltage regulator should be used with an output rating of +5 Vdc at 0.5 amperes. Mount it on the cabinet for heat sinking.

Several 0.1 μF disc capacitors are used on the PC board to bypass the +5 volt line at each IC and reduce logic switching noise. A wire-wrap version should have these capacitors installed first with minimum lead length.

The finished keyer can be mounted in a commercial case or a homemade one such as in the title photo. Some users may want to separate the keypad to move the main keyer circuitry off the desk. In either configuration, be certain to rf bypass all leads into or out of the keyer cabinet.

Locating components isn't difficult.* Most of the

*Drilled and etched PC boards and some parts are available from RADIO-KIT, Box 411, Greenville, N. H. 03048.


TX
470
.01
.02
.01
CR1
CR2
CR4
CR3
330
330
330
330
5.6k
U5
74LS04
RESET
S1
20pF
U1
8748
.01
SPEAKER
1k
DASH
DOT
100
5.6k
U6
7406
.01
.002
R1
25k
2.2k
100k
.01
.002
.01
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.01

analog-to-digital display converter
for the visually handicapped

The circuit described in this article was designed for a visually impaired Amateur to replace his analog panel meter with a large digital display. A variation of the circuit can be used to drive a tactile decimal readout for the blind. This is the primary use of this circuit, but with a little ingenuity it can be adapted to convert any analog device (such as the frequency-readout dial on Amateur gear) to a digital display. For instance, it could be used as an azimuthal readout for an antenna rotor, calibrated directly in degrees of bearing. If so desired, using a thermistor, it could monitor the temperature of a final amplifier or linear amplifier tube compartment, crystal oven, or anything where temperature is critical.

theory of operation

All analog meters are designed with a specific internal resistance and are constructed to display a particular current as "full scale." It is easy to calculate the voltage necessary to produce a full-scale reading, using Ohm's Law, $E = IR$. Thus a 100-ohm, 1-mA full-scale meter requires $100\ ohms \times 0.001\ ampere = 0.1\ volt$ for full scale; a 1000-ohm, 100-micro-ampere full-scale meter requires $1000\ ohms \times 0.0001\ ampere = 0.1\ volt$, and so on.

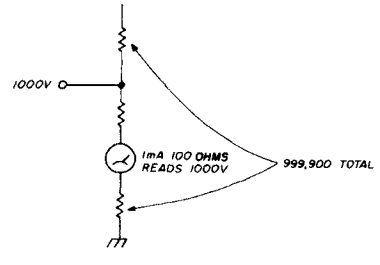


fig. 1. Example using a mater that reads 1 mA full scale. To obtain a full-scale reading of 500 mA with this meter, a 0.2-ohm resistor is connected across the meter, which has an internal resistance of 100 ohms. *Eq. 1* explains how to do it.

To obtain a higher full-scale range for a meter, construct a divider network or shunt network into which the meter is connected. Thus, to obtain a full-scale reading of 500 mA, using a 100 ohm/1 mA full-scale meter, calculate the resistance, to be placed in series with the current through the meter, that will develop a voltage drop of 0.1 volt (the full-scale voltage of the meter) at 500 mA. Using Ohm's Law again, $R = E/I = 0.1V/0.5A = 0.2\ ohm$. (See the circuit in fig. 1.) Likewise, to obtain a full-scale range of 1000 volts, construct a voltage divider with the meter as part of the divider. Again, $R = E/I = 1000V/0.001A = 1\ megohm$. See fig. 2.

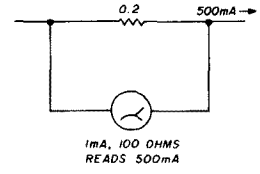


fig. 2. Another example showing how to obtain a full-scale range of 1kV using a voltage divider, with the meter supplying part of the resistance.

If we replace the meter in fig. 2 with a 100-ohm resistor, we can measure the voltage produced across the 100-ohm resistor and construct our voltmeter so that 0.1 volt reads 1000. That's basically what we're

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doing with this converter circuit, using a special analog-to-digital voltmeter.

It's beyond the scope of this article to go into the various methods to convert an analog signal to a digital output. Numerous texts are available covering the subject. Some of the best are the Motorola publications listed at the end of this article.

device selection

This circuit uses the Motorola MC14433 3-1/2 digit A/D converter. The MC14433 is a low-power linear and digital CMOS monolithic dual-slope A/D converter packaged in a 24-pin IC. It provides an accuracy of ±0.05 per cent of reading plus-or-minus one count and provides up to twenty-five conversions per second. The input resistance is 1000 megohms, and its outputs are standard B-series CMOS that will drive one low-power Schottky load. Power consumption is only 8.0 mW typical at 5.0 Vdc. For those interested, the data sheet contains schematics for several voltmeters, including an auto-ranging multimeter with ac and dc full-scale ranges from 200 mV to 200 V; 2 mA to 2 A; and 2 k to 2 megohms.

This circuit uses a finely adjustable reference voltage for the MC14433 to force it into giving any full-scale reading desired (up to 1999). By switching in a number of reference voltages, we can obtain a meter with *any* number of full-scale ranges.

Methods are available to allow any number of digits to be displayed, but this circuit is limited to displaying three and one-half digits to reduce cost and circuit complexity.

circuit description

Referring to fig. 3, the MC14433 uses two external resistors and two external capacitors to set its internal clock and ramp. Since analog ground, V_{AG} must be at least 2.8 volts above circuit ground, V_{EE}, we

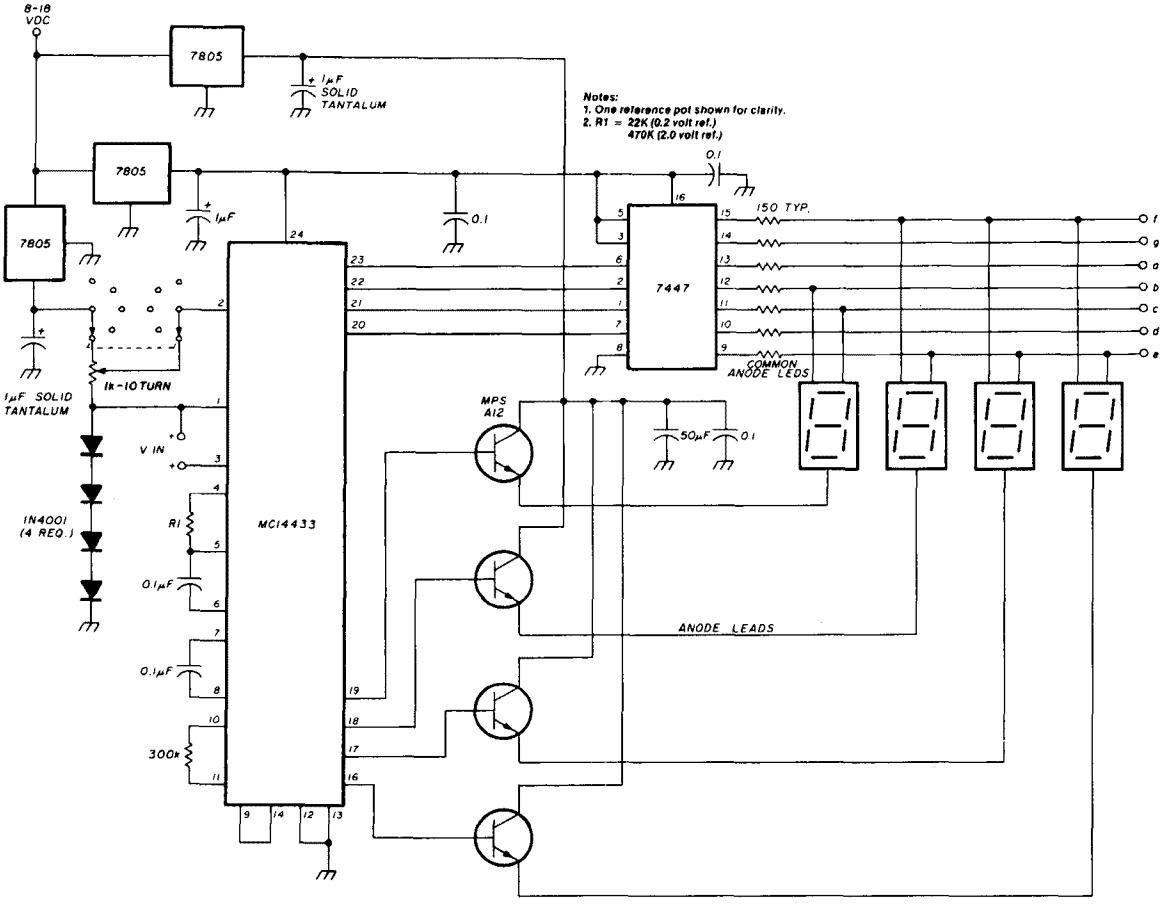


fig. 3. Schematic of the A/D converter using the Motorola MC14433 to drive a MC7447 seven-segment decoder-driver for the LED readouts.

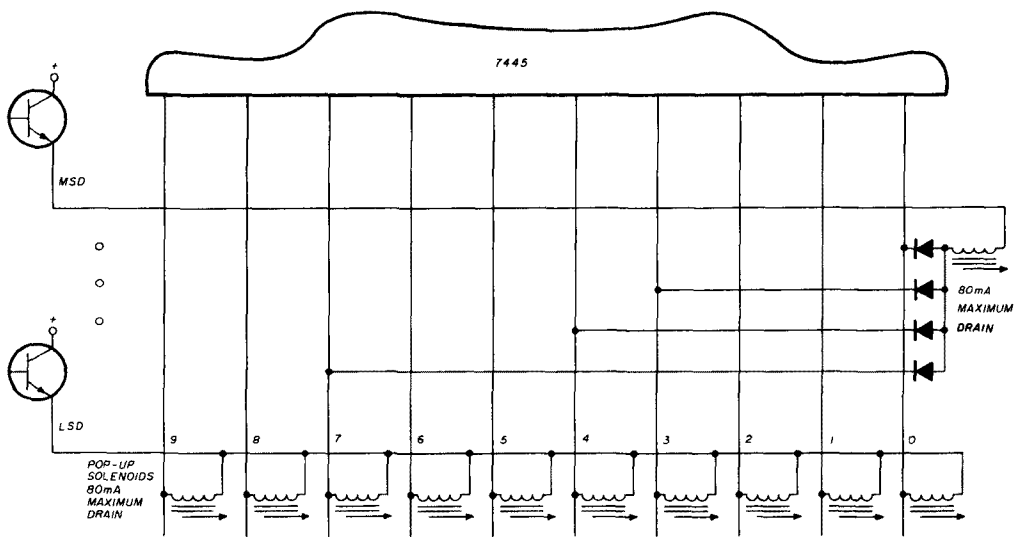


fig. 4. Alternative scheme using an MC7445 ten-line decoder IC for pop-up solenoids (tactile readouts).

use four silicon diodes between V_{AG} and ground (V_{EE} and V_{SS}), giving a voltage drop/separation of 2.8 volts (4 × 0.7 volt). We need either 2 or 0.2 volts for V_{REF}, depending on the range we must measure and the value we select for R1, so we use a 7805 regulator (5 volt) as an accurate voltage source and connect it through a 1k, ten-turn pot (available as surplus in many places) to V_{AG}. Since V_{AG} is 2.8 volts above ground, we have 2.2 volts available across the pot, (*5.0V − 2.8V*) or 0.22 volt per turn of the ten-turn pot. This voltage is adjusted during calibration for new full-scale readings.

The *Q* outputs of the MC14433 (pins 20-23) are fed to a 7447 seven-segment decoder-driver for LED readouts or to a 7445 ten-line decoder-driver for tactile readouts. (See fig. 4.) Note that only segments b and c are connected to the MSD (most significant digit) readout, fig. 3. The digit selects (pins 16-19) then enables each digit in turn through Motorola MPS A12 NPN transistor switches. You may use as large a digital display as desired, as the LEDs or solenoids are mounted external to the decoding and voltmeter circuitry for convenience.

Constuction of the circuit is straightforward, using normal PC techniques.* Care must be taken to shield the circuit and rf bypass the input and output leads, as the circuit can generate small amounts of rf hash due to its clock rate. I haven't found this to be objectionable except during very weak signal reception, so shielding is recommended.

The input voltage to the 7805s can be anywhere from 8 to 18 Vdc. I use a rectified and filtered filament line on my rig. You will experience less dissipation from the 7805s if you use a voltage closer to 8 than 18 volts.

The finished board can be mounted anywhere in the rig, as long as it is shielded from rf-sensitive areas. If at all possible, mount the new range switches onto the existing meter range switch. It's worth replacing the old switch with one that will switch everything.

calibration and installation

To replace an existing panel meter, determine the internal resistance and full-scale current of the meter.

1. *As accurately as possible* measure a resistor of the same nominal value as the internal resistance of the meter for example, 100 ohm, 1 k, and so on.
2. Disconnect the meter from the circuit and connect the leads to the new resistor. If the meter is not removed from the panel, single-lug terminal strips mounted to the meter binding posts make excellent mounts for the new resistor.
3. Now, *as accurately as possible*, measure the

*I will supply PC boards, kits, or completed units to those submitting proof of visual impairment, at my cost. The number and values of scales desired, and the replaced meter information (resistance and full-scale current), must be specified when inquiring about completed units and kits. Please send a self-addressed stamped envelope with your inquiry — **KB7JW**

voltage produced across the new resistor at each setting of the meter range switch.

4. Use **eq. 1** to calculate the correct digital reading:

$$\left[\frac{V_{meas}}{(R_{repl})\ (I_{meter})}\right] Range_{fs} = digital\ reading \quad (1)$$

where V_{meas} = measured voltage (volts)

R_{repl} = meter replacement resistance (ohms)

I_{meter} = meter full-scale current (amperes)

$Range_{fs}$ = meter full-scale range reading

Adjust each reference potentiometer to obtain the correct reading at each range setting.

Thus, using a 100-ohm resistor to replace a 1-mA full-scale meter, a voltage reading of 0.07 volt should read:

$$\left[\frac{0.07}{(100)\ (0.001)}\right] 500 = 0350$$

for a full-scale range of 500 mA. Similarily, if your resistor is 100 ohms and replaces a 100-microampere meter, and your range is 500 mA full scale, 0.05 volt will read:

$$\left[\frac{0.05}{(1000)\ (0.001)}\right] 500 = 0250$$

(Leading zeros are not blanked.)

As you can see from **eq. 1**, the accuracy of your new readout will be no better than the accuracy with which you measure the new resistor and the voltages produced across it.

conclusion

Although intended primarily as a panel-meter replacement, this circuit may find almost unlimited uses in the Amateur station. If you design a PC board, do as I did and leave at least one blank spot on the function switch so you can add another function switch for expansion as you find more and more uses for the circuit. I hope you find this device as useful as I have.

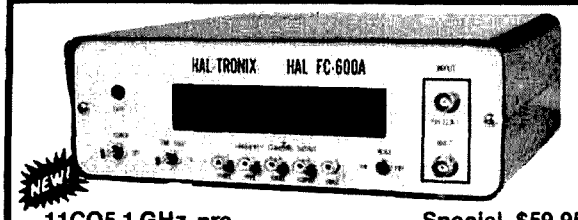
bibliography

Motorola publications:

MC14433	Data sheet
AN471	Analog-to-Digital Conversion Techniques
AN557	Analog-to-Digital Cyclic Converter
AN559	Simple Ramp A/D Converter
AN702	High-Speed Digital-to-Analog and Analog-to-Digital Techniques
AN713	Binary D/A Converters Can Provide BCD-Coded Conversion
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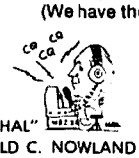
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the Kenscan 74

An inexpensive scanner and preset memory adapter for the Kenwood TR-7400A transceiver

Vhf transceiver design began with single-crystal control, then frequency synthesizers were added to cover an entire band. The newest radios have preset frequency memories and microprocessor scanning control. One purpose of Amateur Radio is to improve the state of the art. Another is building your own circuits. Some of us aren't designers, so I'd like to share this simple scanning module with those who want to improve the Kenwood TR-7400A transceiver. The module is inexpensive and has improved the operation at my station. I call it the Kenscan 74.

functional description

The Kenscan 74 module can store up to sixteen preset frequencies. Each can be selected individually in the step mode or scanned in the scan mode. Scanning will stop when the receiver squelch indicates an active frequency or when the transmitter is keyed. Scan rate is nominally four per second.

Scan is held for about seven seconds after a receiver frequency becomes clear. This pause allows you to pick up the microphone and press the transmit button. Scanning is then stopped and normal transmit/receive operations are possible. Scanning will remain at one frequency until reset by the Kenscan 74 module CLEAR button. Scanning will resume if the microphone button is untouched.

Step mode allows single-button manual scan. Preset channels are selected in groups of 2, 4, 8, or 16 frequencies. Either mode is especially convenient when operating mobile in heavy traffic or when changing a predetermined frequency.

Frequencies to be preset are first selected by the TR-7400A controls. The Kenscan 74 module memory is then loaded by using a single pushbutton. Memory contents are made available to the TR-7400A display and internal PLL frequency control. Once loaded, each frequency setting is held in separate memory locations and recalled with a single button.

Kenscan 74 module circuits are placed between the Kenwood panel controls and internal PLL circuit. Conversion doesn't alter existing Kenwood circuit boards; module wiring isn't critical. Parts count is minimal: only fourteen integrated circuits and two transistors. Layout isn't critical. The design offers many advantages at little expense.

memory and memory control

Fig. 1 is a block diagram of the Kenscan 74 mod-

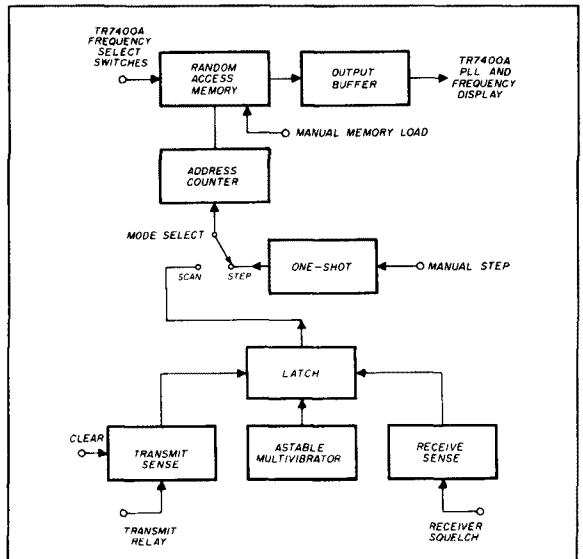


fig. 1. Kenscan 74 block diagram.

By Kenneth R. Fletcher, WB7QYB, 4080 SW 193rd, Aloha, Oregon 97007

ule. Three random access memory (RAM) ICs store the frequency switch settings. Each RAM is four bits by sixteen words; three RAMs are required to hold sixteen ten-bit words.*

The 74189 bipolar RAM memory IC (fig. 2) has inverted outputs. An inverting buffer is placed between RAM output and Kenwood control circuits to restore the original switch data. The RAMs are normally in read mode; a frequency word is always present at the output, depending on the memory address from the counter.

The sixteen-state address counter is set by either step-or scan-mode clocking. RAM addressing is thus one of sixteen stored frequency settings. Setting a particular address, then selecting a frequency and pressing the LOAD switch (fig. 2) will write the frequency setting into the RAM. Releasing the LOAD switch will set the Kenwood frequency control and display.

Fig. 2 is the Kenscan 74 module schematic. U5, U6, and U7 are the RAMs. U8 and U9 are the CMOS RAM output buffers. U3 is the RAM address counter. U3 is CMOS, so noninverting buffer U4 is used to provide sufficient drive for three TTL RAMs.

The number of address states produced by U3 is controlled by the CHANNEL SELECT switch, S2. In the 2 position, reset pin 9 of U3 is connected to the second stage. Counter output is 0000, then 0001. On reaching 0010, the second-stage high state causes a reset to all-zero; address count is limited to two. Positions 4 and 8 will reset on third- and fourth-stage high states, respectively, while the 16 positon allows a full count.

mode control

The counter is clocked in the step mode by one-shot U2. U2 is triggered by STEP switch S3, and the counter advances once. Scan-mode clocking is controlled by U1, a 555 timer used as an astable multivibrator with a rate of 4 Hz.

While STEP/SCAN switch S1 selects the counter clock, U1 output must pass through latch U10, which will stop the scan-mode clock when U12, Q1, and Q2 detect a receiver input from the TR-7400A squelch.†

Voltage-follower U12A input pin 3 is connected to Q13 collector on the receiver board inside the Kenwood. Q13 collector goes to about +1.8 volts when a signal is received; to +0.1 volts with no signal. Q1 and Q2 saturate when the buffered squelch voltage is high. C6 is normally charged to +5 volts through R9 and R10 but is discharged to ground by Q2 through R11. Voltage follower U12B couples the charge of C6 to the AND gate formed by U11. Latch U13 is normally high, so a low at AND gate pin 5 will cause its output pin 10 to be low. D input pin 5 of U10 is now low, so U10 latches and prevents scan pulses from reaching the address counter.

When the squelch voltage input drops to +0.1 volts, Q1 and Q2 are cut off and C6 begins charging through R10 and R9 to +5 volts. After seven seconds (adjustable by R10), C6 will charge high enough to bring the AND gate pins 5 and 10 high. U10 pin 5 is now high, scan pulses from U1 are passed through U10, and scanning resumes.

Latch flip-flop U13 is connected to the receive-transmit relay that supplies +12 volts when the transmitter is keyed. Zener CR1 clamps the transmit level to +5.1 volts at U13 clock pin 3. U13 D input pin 5 is tied high. U13 will toggle on the first transmit key pulse and remain set; Q pin 2 will drop low and inhibit AND gate U11A pin 6. U10 is then latched, and scanning stops.

U13 will lock up and scan until manually reset by the CLEAR switch. A squelch break or transmit-key pulse will stop scanning, but manual reset is required after transmitting to restore a scan.

The voltage regulator for the module is an LM340T-5 rated at 1.5 amperes. An LM7805CT will work equally well. Both have TO-220 cases.

assembly

The circuit is fairly dense so I chose wire-wrap assembly. Layout isn't critical but the module must be larger than 12 square inches (80 square cm). Control switches may be mounted off the board. I prefer ribbon cable for both switch wiring and the 34 conductors necessary to interface with the Kenwood transceiver. Harmonica connectors, such as the 3M No. 3414, make neat, low-profile connections for compact places such as inside the transceiver.

Position the wire-wrap sockets and arrange connectors close to the IC locations. Wire wrapping should begin with all power and ground connections. Verify all wiring with an ohmmeter before inserting the ICs. It's much easier to correct wire-wrap mistakes early; the deeper the wiring, the harder it is to trace wires. Regulator U14 can be checked for operation at this point.

*Word is a term used to describe several bits in parallel for a specific data or value function.

†The CD4042 latch in U10 is not a conventional D flip-flop. Holding polarity-pin 6 high with clock-pin 5 high will pass any D input at pin 7 to output pin 10. D input will be latched into the output when pin 5 goes low; output is held (latched) until the clock returns to a high state.

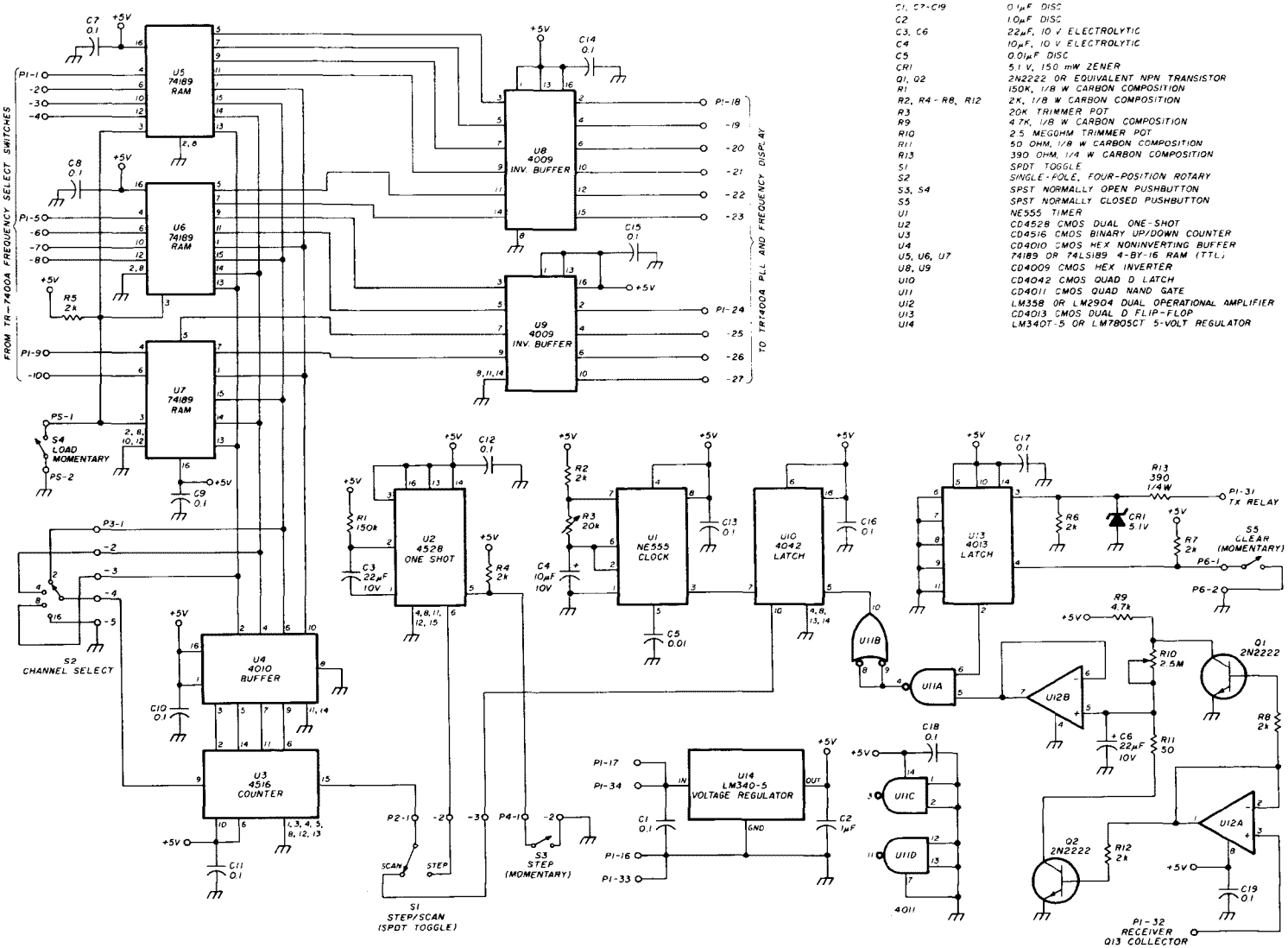


fig. 2. Schematic diagram of the Kenscan 74 module. U5-U7 are the RAMs; U8, U9 are CMOS RAM output buffers; U3 is the RAM address counter.

table 1. Interface connections.

outputs from frequency-select switches (square pins)	scanner module connector P1	input to PLL and display
A3	1	
B3	2	
A2	3	
B2	4	
C2	5	
D2	6	
A1	7	
B1	8	
C1	9	
D1	10	
GND	16,33	
+12 V	17,34	
transmit relay	31	
Q13 collector	32	
	18	A3
	19	B3
	20	A2
	21	B2
	22	C2
	23	D2
	24	A1
	25	B1
	26	C1
	27	D1
	28,29,30	no connection
5V		5V
ØK		ØK
5K		5K
CT1		CT1
CT2		CT2

Kenwood TR-7400A modifications

This portion may be the most undesirable part of the project but it isn't difficult. To interface the scanner module, the mating interface connectors must be wired inside the Kenwood transceiver in the following manner.

Find the place on the TR-7400A schematic where the frequency programming information from the front-panel switches goes through a harmonica connector to two other boards. This connector is marked ØK, 5K, A2, C2, and so on. *Stop!* The connector is *not* marked correctly on the schematic. Call the pin marked ØK as 1. There's a space and a 5K marked on the schematic as the next pin. The space in the plug should really be between two pins marked A3 and 5V. The other plug is also misdrawn: the space should be moved from between CT1 and CT2 to between E and B1. Remarking the schematic will eliminate any confusion between the physical wiring and the schematic.

Next remove both top and bottom covers, then remove all knobs. The MHz lever pulls straight off, while all others have setscrews. Remove the four screws holding the front panel. Pull the display modules straight up, which will expose a board that must be loosened and moved aside (this board has two screws on each end). The frequency control connectors will now be visible. Identify each connector with the corrected schematic data.

The Kenwood TR-7400A connectors should now be replaced with the scanner module interface connector. The square pins are mated to the frequency-control switches, while the plugs are inputs to the

table 2. Troubleshooting chart.

problem	possible cause	solution
nothing works	no 5 V	Check U14
	no GND to scanner	check P1-16, P1-33
	no 12 V to regulator	check P1-17, P1-34
will not load frequency	pin 3 of U5, U6, U7 not pulled low	check S4 and wiring to P5
Display incorrect when LOAD is pushed	wiring error A1-B3	check P1-1 through P1-10
	broken wire	check P1-18 through P1-27
will not step	U2 wired incorrectly	check wiring
	S1 wired incorrectly	check wiring
	S3 wired incorrectly	check wiring
will not SCAN	S1 wired wrong	check wiring
	S2 wired wrong	check wiring
	no clock pulse	check U1-3, U10-10, U3-15
	U10 latched	push CLEAR
will not stop at busy channel	no stop signal	check squelch input from Q13
	scan rate too fast	set R3 for 4-Hz rate

display and PLL circuitry. With the aid of **table 1**, reconnect each wire to the scanner module interface connector. Note that five wires marked 5V, ØK, 5K, CT1, CT2 are jumpered *inside* the transceiver and do not go to the scanner module.

Once the interface connector is installed, reassembly is in the reverse order of assembly. Make certain that all knob indices are correct. Proceed with the scanner module and switch cabinet.

final test

Be sure that the regulator on the scanner module has an output of +5 volts before any ICs are installed: overvoltage will damage the RAMs. Eliminate any static electricity possibilities when handling the CMOS ICs or when handling the unconnected module.

With all assemblies and connectors ready, connect the scanner module to the TR-7400A. If any problems occur with the Kenscan 74, refer to the troubleshooting chart in **table 2**.

programming

Place the CHANNEL SELECT switch in the 2 position and the STEP/SCAN switch in STEP. Dial up the first frequency and press the LOAD switch. Push the STEP switch to change memory address. Dial the second frequency and push LOAD. Set the STEP/SCAN switch to SCAN and push CLEAR. The two preset frequencies should now be scanning. Step mode can select either frequency at a single touch of the STEP switch.

The other fourteen memories can be loaded and accessed in the same manner. The CHANNEL SELECT switch will allow you to preset two, four, eight, or sixteen combinations.

etched-circuit boards

At this wiring, etched circuit boards are being designed. For further information on these boards or kits, send a self-addressed, stamped envelope to the author. If you have any problems with the circuit, send an SASE with a detailed description of the problem and I'll try to help.

Author WB7OYB has a versatile adapter with a noncritical interface. While bells and whistles have been kept to a minimum, enough unused IC functions are available to experiment with your own additions. For example, the preset input pins of U3 could be used with a separate switch bank to add individual selection. You could scan eight frequencies with the CHANNEL SELECT switch set at 8 then use the other eight memory locations for fixed frequencies. A bit of study of the CMOS data sheets will show how this could be done. It has lots of possibilities. **Editor.**

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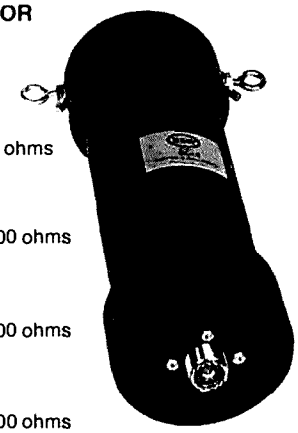
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More Details? CHECK—OFF Page 110

quick and simple antenna match

A candidate for monoband mobile work

One component and a length of transmission line will make a quick and simple antenna match. Sound too good to be true? The method borrows an old microwave technique and is limited to narrow bandwidths. It's useful for restricted monoband operation, especially for mobile work.

Familiarity with the Smith chart is required.[1] You must have a good measurement of the antenna impedance at the transmitter end.[2,3] The component value and extra line length can be found by graphic or numerical methods. This matching scheme is best explained by a quick review of certain parts of the Smith chart.

intercepting the R_O circle

A key element of the Smith chart is the resistive circle lying on the bisecting line and passing through chart center and infinite resistance. This circle is marked as R_O equal to Z_0 for a specific impedance or unity on a "normalized" chart.*

This simple matching method requires adding a line to move the measured impedance in a clockwise direction until the rotated impedance point intersects the $R_O = Z_0$ circle at either of two places. A clockwise rotation is marked "toward generator." Once at the R_O circle intersection, the new reactance may be read directly.

*Normalized charts have all impedances divided by characteristic impedance of a line. These charts can be used with any impedance.

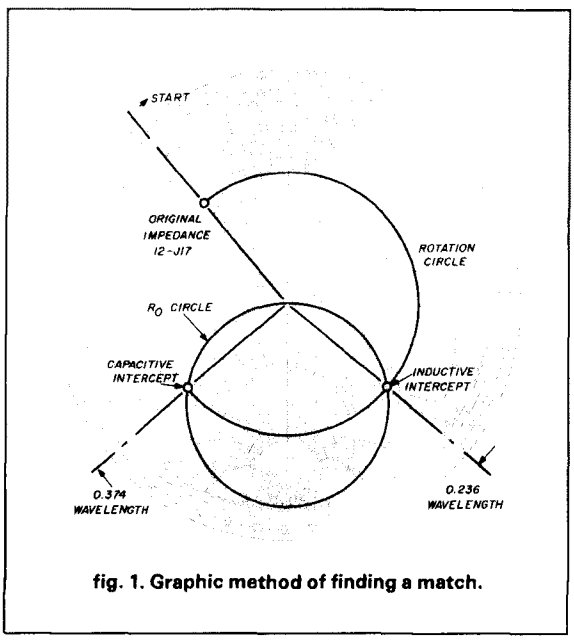


fig. 1. Graphic method of finding a match.

Matching requires adding an *opposite* reactance in series with the new end impedance. It is simply series resonating, so that only the resistive part remains. You have reached the perfect match!

a graphical method

Fig. 1 shows the matching scheme. Suppose you measure an impedance of 12-j17 ohms at the existing-line transmitter end. Using a drafting compass

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pivoting on chart center, draw a circle through this impedance point until the $R_O = Z_O$ circle is intercepted. Next, draw radial lines from chart center through the original impedance and each R_O circle intercept. Radial lines should go through the circular wavelength scales.

Note the reactance component at the R_O circle intercept. In this example it's about 84.5 ohms. Calculate a capacitor and inductor value for this reactance

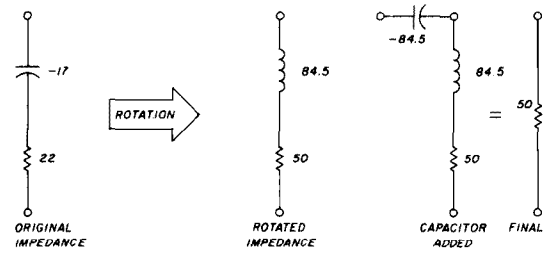


fig. 2. Schematic representation of the Smith chart operations.

at the original impedance-measurement frequency; choice of capacitor or inductor depends on the added line length.

Total the fractional wavelength, in a clockwise direction, from original impedance radial to each of the R_O circle intercept radials. Inductive-reactance side intercept should total 0.236 wavelength; series capacitance is used at this intercept. Capacitive reactance intercept occurs at 0.374 wavelength, and a series inductor would be required here.

The sequence of events is shown in **fig. 2**. Rotating the original 12-j17 ohm impedance by 0.236 wavelength (adding a line) will make it 50+j84.5 ohms. Adding a series capacitor of $-j$84.5 ohms results in a final impedance of 50+j0 ohms.

The antenna hasn't changed impedance, but the load presented to the transmitter is now purely resistive; a better power transfer occurs. The original impedance has a 4.67:1 VSWR and may be out of the range of a tuner or may upset an ALC circuit.

line lengths

This quantity is easily determined by

$$Length = k \times wavelength \times velocity\ of\ propagation/frequency\ (MHz) \quad (1)$$

where: K = 984 for length in feet,
300 for length in meters

Propagation velocity depends on the added transmission line and would be 0.659 for common polyethylene dielectric coaxial cable. The example in feet at 3.9 MHz with RG-58A cable would be:

$$984 \times 0.236 \times 0.659/3.9$$
$$= 161.86/3.9 = 39.24\ feet$$

This length of line might shock 80-meter fans at today's prices. An advantage is that the added line is *indoors*; some previously used outdoor line may still be good.

numerical methods

Previously published formulas can be rearranged for those lacking Smith charts.[4] Assigning R_O as the added line characteristic impedance and $R_L + jX_L$ as the original transmitter-end measurement, series reactance is:

$$X_s = \sqrt{[R_O(R_O^2 + X_L^2)]/R_L + R_O(R_L - 2R_O)} \quad (2)$$

This reactance is both capacitive and inductive. It represents the inductive-component-side intercept and the added capacitor reactance. Calculation from the example would be:

$$X = \sqrt{[50(2500 + 289)]/12 + 50(12 - 100)}$$
$$= \sqrt{7220.83} = 84.98\ ohms$$

Line-length formula results in a phase angle, β, that must be divided by 360 degrees to obtain fractional wavelength in **eq. 1**.

$$\beta = arctan\ \frac{R_O(R_O - R_O)}{R_O X_L + R_L X} \quad (3)$$

The X term with no subscript is the value from **eq. 2**. Example calculations are:

$$\beta = tan^{-1}\left[\frac{50(50 - 12)}{50(-17) + 12(84.98)}\right]$$
$$= tan^{-1}\left[\frac{1900}{169.76}\right] = 84.89\ degrees$$

Dividing 84.98 by 360 gives the wavelength of 0.236, and **eq. 1** is used for physical length.

A rotation greater than 0.25 wavelength gives a negative angle for β. Simply add 180 degrees for the correct angle. The reason for a negative result is that an arctangent result can only be within ±90 degrees. The negative angle represents a counterclockwise rotation. Since the Smith chart is only 180 degrees in circumference, adding 180 degrees to a negative result will give a correct clockwise rotation angle.

Suppose another measurement was 22.5-j50 ohms. Numeric equations would yield X of 85.07 ohms and β of −66.92 degrees. Adding 180 degrees to β would give the correct 113.08 degrees or 0.314 wavelength rotation.

case history of a quick match

A newly moved ham wanted to get on 20 meters in

table 1. Calculated data of the 20-meter dipole matching example. Columns marked "original" and "measured" are from RX noise bridge readings, others are ideal conditions. Capacitive reactance for 200 pF. Target frequency for optimum match was 14.15 MHz.

	original		new Z at 12-foot		ideal new $Z + X_C$		measured	
F (MHz)	impedance	VSWR	extension	X_C	impedance	VSWR	impedance	VSWR
14.00	39.3 − j50.8	3.04	25.7 + j34.2	−56.8	25.7 − j22.6	2.45	26.6 − j22.1	2.35
14.05	32.6 − j45.1	3.11	29.0 + j40.5	−56.6	29.0 − j16.1	1.98	30.3 − j15.3	1.88
14.10	27.8 − j41.3	3.27	31.7 + j46.6	−56.4	31.7 − j9.8	1.67	32.7 − j8.6	1.60
14.15	25.1 − j36.1	3.22	37.7 + j52.3	−56.2	37.7 − j3.9	1.35	39.7 − j3.5	1.28
14.20	23.3 − j31.6	3.15	45.2 + j57.4	−56.0	45.2 + j1.4	1.11	47.0 + j1.0	1.07
14.25	23.2 − j24.9	2.80	60.7 + j58.2	−55.8	60.7 + j2.4	1.22	62.0 + j1.0	1.24
14.30	24.5 − j17.5	2.36	80.7 + j47.0	−55.6	80.7 − j8.6	1.64	78.8 − j9.6	1.52
14.35	25.8 − j10.5	2.05	93.7 + j25.0	−55.5	93.7 − j30.5	2.14	90.9 − j28.7	2.07
14.40	27.7 − j2.8	1.81	90.5 − j2.7	−55.3	90.5 − j58.0	2.74	90.1 − j56.1	2.68

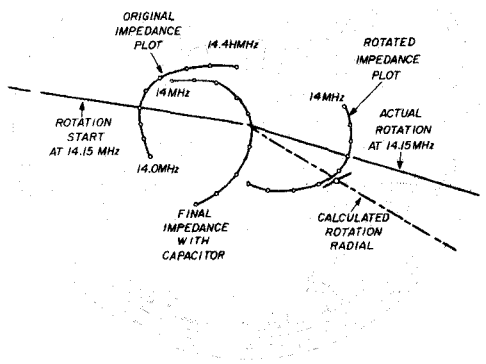


fig. 3. Impedance plots of 20-meter dipole matching.

a hurry with a temporary dipole. The antenna tuner had been mislaid and the transmitter did not seem to load correctly. RX noise bridge readings and calculations showed a reasonable VSWR condition given in the left columns of **table 1**. A better match was desired at 14.15 MHz.

Numerical calculations resulted in 61.90 ohms for X, 101.42 degrees or 0.282 wavelength added line. This translated to 181.7 pF series capacitance and 12.92 feet (3.94 meters) of line. Smith chart plots are given in **fig. 3** with the dash-dot line marking the 50-ohm intersection at 14.15 MHz.

Two six-foot (1.83-meter) lengths of RG-58C were available and a junkbox search came up with two 100-pF transmitting mica capacitors along with a small box having appropriate cable connectors (to house the capacitors). HP-67 calculator work indicated this combination should do well.[5] The ideal rotation plus series capacitance is plotted in **fig. 3**; ideal and actual results are in **table 1**. Total time for measurement and matching took half of a Sunday afternoon.

This type of match is no substitute for a good antenna tuner but shows what can be done quickly and with fixed components. The rotated impedance in **fig. 3** is slightly more than 90 degrees away from the original. Plot points of the ideal case are on each resistive-part locus, differing only by the series reactance.

applications

Monoband mobile work seems the best application for this simple matching scheme. Restricting the frequency to phone bands permits matching to within 2:1 VSWR. A fixed series reactance should survive vibration better than a variable tuner; it should be in a sturdy metallic box since both ends are above ground. Added cable can be tucked away in the trunk or behind seat backs. Do *not* put any cable under adjustable seats; slashed cable is the invariable result.

Although a simple technique, the method requires accurate measurement and calculation.[6,7]

references

1. James Fisk, W1DTY, "How to Use the Smith Chart," *ham radio*, November, 1970, page 16 (reprinted March, 1978, page 92).
2. Robert A. Hubbs, W6BXI, and A. Frank Doting, W6NKU, "Improvements to the RX Noise Bridge," *ham radio*, February, 1977, page 10.
3. Paul White, W6BKX, 'BKX Bridge," *73*, November, 1969, page 32.
4. Leonard H. Anderson, "Antenna Bridge Calculations," *ham radio*, May, 1978, page 34.
5. *Program 02603D*, HP Users' Library, 1000 N. E. Circle Blvd., Corvallis, Oregon, 97330 (a similar HP-97 program is *Program 02258D*; each is $6.00 and includes a recorded card).
6. T.J. Anderson, WD4GRI, "Noise Bridge Calculations," *ham radio*, May, 1978, page 45 (TI-58, 59 programs).
7. C.R. MacCluer, W8MQW, "Numerical Smith Chart," *ham radio*, March, 1978, page 104 (HP-25 programs).

ham radio

transmission-line circuit design

Using distributed resonant circuits for uhf/vhf transmission lines

In part 1 of this article (*ham radio*, November, 1980) I addressed the governing expressions for calculating resonant transmission-line parameters. Included were data on design relationships such as efficiency, coupling, and resonating capacitance. Programs for the Hewlett-Packard HP-67/97 calculator were detailed using the HP-97 printer capability.

This part of the article examines the geometry of the first four configurations of twelve different transmission lines in common use at 50 MHz and above (50 MHz is not a lower limit, however). The parameters for resonant-circuit design are described for:

1. Coaxial lines.
2. Parallel plates.
3. Parallel wires in air.
4. Single wire over a plane.

Subsequent issues of *ham radio* will present similar data on the remaining transmission-line configurations.

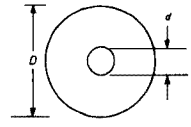
line configurations, graphs, and calculator programs

The critical parameters of the twelve transmission-line configurations previously identified in fig. 1 (*ham radio*, November, 1980) are described. Graphic solution of characteristic impedance, Z_0, as a function of the physical geometry of each line is given where practical. Also HP-67/97 calculator programs are provided for each line configuration, permitting rapid solution for the selected variables or variables. For most cases the programs are written to permit the reverse solution to be calculated, thereby checking both accuracy of data entry and program.

The programs are not optimized to minimize steps. In all cases the 224 steps available in the HP-67/97 are sufficient to calculate the desired results. In some cases, more than one line configuration can be programmed on a magnetic card. The final choice rests with each user as to exactly what line configurations are grouped together to satisfy design requirements.

Following each program is a table that shows which registers are used in the program and what they contain. Tables indicating how the program is controlled are included and, where useful, a sample problem is given. References give the source data from which the transmission-line parameters were calculated.

coaxial line



This is the basic transmission-line configuration used in resonant circuits. The governing equation for transmission-line parameters (reference 4) is:

$$Z_0 = \frac{138}{\sqrt{\epsilon_r}} \log_{10} \frac{D}{d} \qquad (19)$$

where Z_0 = transmission line impedance (ohms)
ϵ_r = dielectric constant (air = 1)*
D = inside major diameter
d = outside minor diameter

Fig. 8 shows the graphical relationship of D/d versus Z_0 for Z_0 between zero and 300 ohms. These values were calculated for the HP-67/97 program shown in table 8. The storage register contents are in table 9; program control is in table 10. The program assumes that the dielectic constant, ϵ_r, is 1.0; that is, ϵ_r is equal to air if no value is entered.

By H.M. Meyer, Jr., W6GGV, 29330 Whitley Collins Drive, Rancho Palos Verdes, California 90274

Table 8. HP-67/97 program for calculating D/d and Z_0 for coaxial lines.

step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code
001	*LBLA	21 11	026	x	−35
002	√X	54	027	1	01
003	STO0	35 00	028	3	03
004	RTN	24	029	8	08
005	*LBLB	21 12	030	÷	−24
006	÷	−24	031	10x	16 33
007	*LBL1	21 01	032	STO1	35 01
008	STO1	35 01	033	RTN	24
009	LOG	16 32	034	*LBLD	21 14
010	1	01	035	STO1	35 01
011	3	03	036	GTO1	22 01
012	8	08	037	*LBL2	21 03
013	x	−35	038	R↓	−31
014	PCL0	36 00	039	1	01
015	X=0?	16-43	040	STO0	35 00
016	GSB2	23 02	041	÷	−24
017	÷	−24	042	STO2	35 02
018	STO2	35 02	043	R/S	51
019	RTN	24	044	*LBL3	21 03
020	*LBLC	21 13	045	1	01
021	STO2	35 02	046	STO0	35 00
022	*LBL4	21 04	047	R↓	−31
023	RCL0	36 00	048	GTO4	22 04
024	X=0?	16-43	049	R/S	51
025	GSB3	23 03			

table 9. Register contents for HP-67/97 program for calculating D/d and Z_0 for coaxial lines.

STO 0	$\sqrt{\epsilon_r}$
STO 1	D/d
STO 2	Z_0

table 10. HP-67/97 program control for calculating D/d and Z_0 for coaxial lines.

enter	ϵ_r	press A
calculates	Z_0	
enter	D	press ENTER (↑)
enter	d	press B
calculates	D/d	
enter	Z_0	press C
calculates	Z_0	
enter	D/d	press D

Note: If no value for ϵ_r is entered, program assumes $\epsilon_r = 1 = air$.

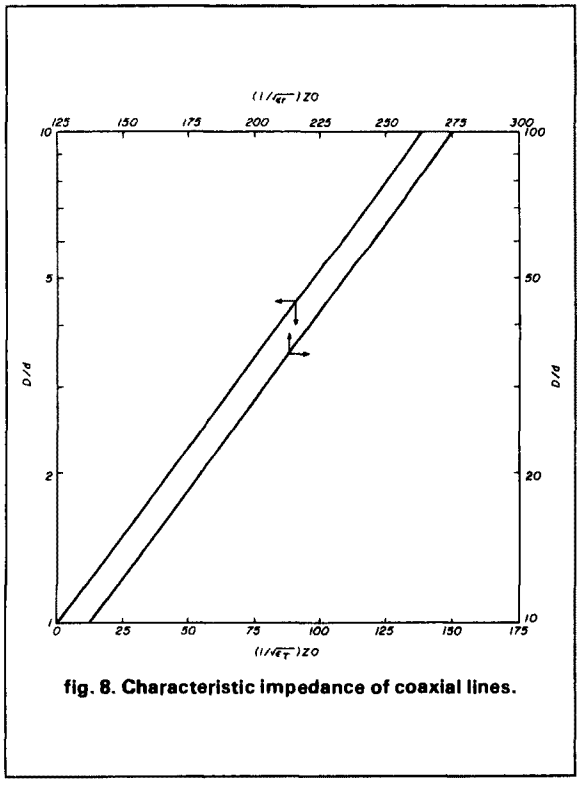
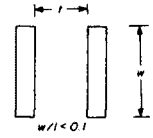


fig. 8. Characteristic impedance of coaxial lines.

parallel plates



This baseline configuration is often used with vacuum tubes. It is also used as a baseline geometry in calculating striplines between and over a ground plane. It is important to note that fringe and distributed capacitance effects, which can introduce substantial errors, are not considered. In addition, the thickness of the lines is assumed to be zero.

The governing equation (reference 4) as shown for this configuration is:

$$Z_0 = \frac{377}{\sqrt{\epsilon_r}} \log_{10} \frac{w}{t} \qquad (20)$$

where Z_0 = line impedance (ohms)
w = line width
t = minimum distance between lines
$w/t > 1.0$

Table 11 is the program for the HP-67/97, **table 12** shows the storage registers used, and **table 13** shows program control. **Fig. 9** shows the relationship of w/t with respect to Z_0. The program assumes $\epsilon_r = 1$ if no value is entered.

Table 11. HP-67/97 program for calculating Z_0 and w/t for parallel plates.

step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code
001	*LBLA	21 11	026	÷	− 24
002	STO0	35 00	027	STO3	35 03
003	$\sqrt{X}$	54	028	*LBL4	21 04
004	STO1	35 01	029	LOG	16 32
005	RTN	24	030	3	03
006	*LBLB	21 12	031	7	07
007	STO2	35 02	032	7	07
008	*LBL1	21 01	033	x	− 35
009	RCL1	36 01	034	STO4	35 04
010	X = 0?	16-43	035	*LBL2	21 02
011	GSB9	23 09	036	RCL1	36 01
012	x	− 35	037	X = 0?	16-43
013	3	03	038	GSB8	23 08
014	7	07	039	÷	− 24
015	7	07	040	STO2	35 02
016	÷	− 24	041	R/S	51
017	10^x	16 33	042	*LBL8	21 08
018	STO3	35 03	043	1	01
019	R/S	51	044	STO1	35 01
020	*LBL9	21 09	045	RCL4	36 04
021	1	01	046	GTO2	22 02
022	STO1	35 01	047	*LBLD	21 14
023	RCL2	36 02	048	STO3	35 03
024	GTO1	22 01	049	STO4	22 04
025	*LBLC	21 13	050	R/S	51

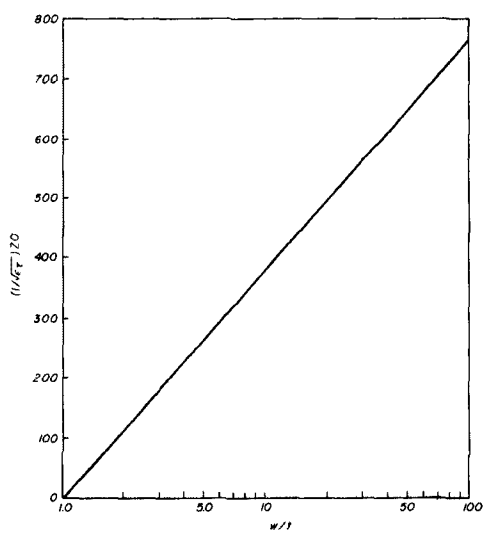


fig. 9. Parallel plate w/t versus Z_0.

table 12. Register contents for HP-67/97 program for calculating Z_0 and w/t for parallel plates.

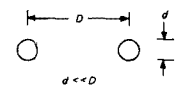
STO 0	ϵ_r
STO 1	$\sqrt{\epsilon_r}$
STO 2	Z_0
STO 3	w/t
STO 4	INTERIM

table 13. HP-67/97 program control for calculating Z_0 and w/t for parallel plates.

enter	ϵ_r	press A
calculates	w/t	
enter	Z_0	press B
calculates	Z_0	
enter	$W1t$	press C
calculates	Z_0	
enter	w/t	press D

Note: If no value for ϵ_r is entered, program assumes $\epsilon_r = 1 = air$.

parallel wires in air



This is the classic balanced transmission line. It is included here for completeness. The exact equation (reference 4) is:

$$Z_0 = 120 \cosh^{-1} \frac{D}{d} \qquad (21)$$

where D = center-to-center spacing between lines
d = outside diameter of each line
Z_0 = line impedance (ohms)

Fig. 10 is a plot of line impedance versus ratio D/d. **Table 14** shows the HP-67/97 program for calculating either the Z_0 or D/d values depending on the available data. **Table 15** shows the storage register content used for the program; **table 16** shows program control.

To calculate $\cosh^{-1} D/d$, the following was used:

$$\cosh^{-1} \frac{D}{d} = \ell n \left\{ \frac{D}{d} + \left[\left(\frac{D}{d} \right)^2 - 1 \right]^{1/2} \right\} \qquad (22)$$

In calculating the converse, assume $\cosh^{-1} = a$, then:

$$\frac{D}{d} = \frac{(e^a)^2 + 1}{2e^a} \qquad (23)$$

Table 14. HP-67/97 program for calculating Z_0 and D/d for parallel lines in air.

step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code
001	*LBLA	21 11	020	*LBL1	21 01
002	STO0	35 00	021	X^2	53
003	1	01	022	1	01
004	2	02	023	−	− 45
005	0	00	024	$\sqrt{X}$	54
006	÷	− 24	025	RCL3	36 03
007	e^x	33	026	+	− 55
008	STO2	35 02	027	LN	32
009	X^2	53	028	1	01
010	1	01	029	2	02
011	+	− 55	030	0	00
012	RCL2	36 02	031	x	− 35
013	2	02	032	STO0	35 00
014	x	− 35	033	R/S	51
015	÷	− 24	034	*LBLC	21 13
016	STO3	35 03	035	÷	− 24
017	R/S	51	036	STO3	35 03
018	*LBLB	21 12	037	GTO1	22 01
019	STO3	35 03	038	R/S	51

table 16. Register contents for HP-67/97 program for calculating Z_0 and D/d for parallel lines in air.

STO 0	Z_0
STO 1	INTERIM
STO 3	D/d

table 16. HP-67/97 program control for calculating Z_0 and D/d for parallel lines in air.

calculates	D/d	
enter	Z_0	press A
calculates	Z_0	
enter	D/d	press B
calculates	Z_0	
enter	D	
enter	d	press D

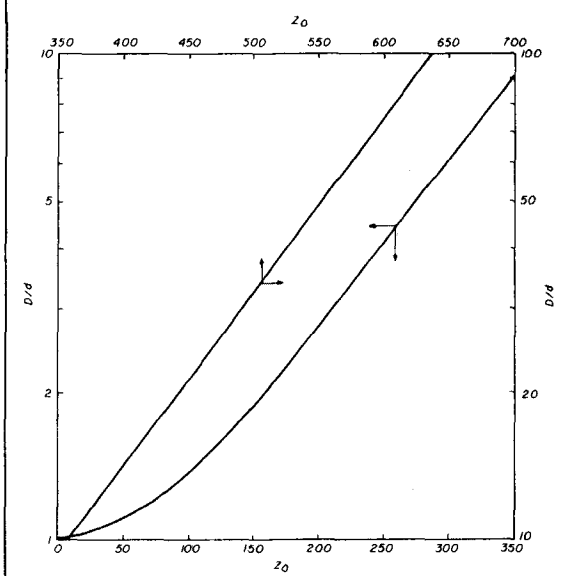
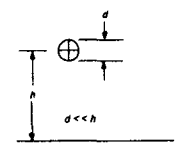


fig. 10. Characteristic impedance of parallel lines.

single wire over a plane



This configuration is often used for resonant circuits to 2 GHz and as the main element of filters in local-oscillator chains. The governing equation (reference 4) is:

$$Z_0 = \frac{138}{\sqrt{\epsilon_r}} \log_{10} \frac{4h}{d} \qquad (24)$$

$$d << h$$

where Z_0 = line impedance (ohms)
ϵ_r = dielectric constant
h = centerline height above the plane of the wire
d = wire diameter

Fig. 11 depicts Z_0 versus h/d for a nominal range of values. Table 17 is the HP-67/97 program for calculating Z_0 or h/d or, given h and d, calculating Z_0. If ϵ_r is not given the program assumes $\epsilon_r = 1$; that is, air. Table 18 shows the storage registers used for the program; table 19 indicates program control.

Table 17. HP-67/97 program for calculating Z_0 and h/d for a wire over a plane.

step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code
001	*LBLA	21 11	028	3	03
002	STO0	35 00	029	8	08
003	$\sqrt{X}$	54	030	÷	−24
004	STO1	35 01	031	STO3	35 03
005	RTN	24	032	*LBL3	21 03
006	*LBLB	21 12	033	RCL1	36 01
007	÷	−24	034	X=0?	16-43
008	*LBL1	21 01	035	GSB8	23 08
009	STO2	35 02	036	x	−35
010	4	04	037	10^x	16 33
011	x	−35	038	4	04
012	LOG	16 32	039	÷	−24
013	1	01	040	STO2	35 02
014	3	03	041	R/S	51
015	8	08	042	*LBLD	21 14
016	x	−35	043	GTO1	22 01
017	STO3	35 03	044	*LBL9	21 09
018	*LBL2	21 02	045	1	01
019	RCL1	36 01	046	STO1	35 01
020	X=0?	16-43	047	RCL3	36 03
021	GSB9	23 09	048	GTO2	22 02
022	÷	−24	049	*LBL8	21 08
023	STO4	35 04	050	1	01
024	R/S	51	051	STO1	35 01
025	*LBLC	21 13	052	RCL3	36 03
026	STO4	35 04	053	GTO3	22 03
027	1	01	054	R/S	51

table 18. Register contents for HP-67/97 program for calculating Z_0 and h/d for a wire over a plane.

STO 0	ϵ_r
STO 1	$\sqrt{\epsilon_r}$
STO 2	h/d
STO 3	INTERIM
STO 4	Z_0

table 19. HP-67/97 program control for calculating Z_0 and h/d for a wire over a plane.

enter	ϵ_r	press A
calculates	Z_0	
enter	h	press ENTER
enter	d	press B
calculates	h/d	
enter	Z_0	press C
calculates	Z_0	
enter	h/d	press D

Note: If no value for ϵ_r is entered, program assumes $\epsilon_r = 1 = air$.

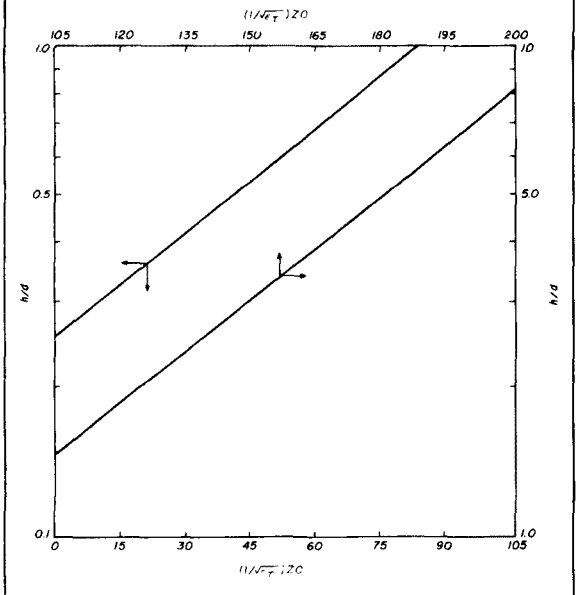


fig. 11. Z_0 versus h/d for a wire over a plane.

In the next series, to be published in a subsequent issue, I shall discuss the geometry and resonant-circuit design of the following line configurations:

1. Circular wire between planes.
2. Parallel wires over a plane.
3. Circular wire in an open trough.
4. Parallel wires between planes/rectangular box.

reference

4. *Reference Data for Radio Engineers*, ITT Corporation, 5th Edition, 1968 (included in subsequent editions).

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ham radio

ham radio TECHNIQUES

Bill Orr W6SAI

We are happy to introduce a new department in ***ham radio*** *by one of the most respected and knowledgeable Amateurs in the world. Bill Orr started his Amateur career in 1934, when he obtained his first license, W2HCE. He has been a prolific contributor to the Amateur literature, having authored more than 100 magazine articles and many books. Perhaps his most famous works are* ***The Beam Antenna Handbook*** *and* ***Radio Handbook,*** *of which he is the editor. Bill's literary style is friendly and easy to read and understand. We hope our readers will enjoy this series of articles, which will contain technical topics of general interest to Radio Amateurs.* ***Editor***

BY WILLIAM I. ORR, W6SAI

Happy New Year 1981! What will the New Year bring to Amateur Radio? We have the prospect of the new 10-MHz band in the near future and the probability that the 160-meter band will be expanded as the Loran-A equipment is deactivated. And, the sunspot cycle will continue its inexorable decline.

You probably won't notice much deterioration in DX conditions on the high-frequency bands this spring, but you might find that 10 meters is noticeably less "DX-y" this coming fall. And by spring, 1982, the slump in 10-meter openings should be quite apparent. So enjoy 10 while you have the chance. Pay attention to 6 meters, too; it might be a long time before 6 meters shows the long-distance communications that seem to be almost a daily occurrence these past years.

the popular triband Yagi beam

This column discusses the triband Yagi beam for 20, 15, and 10 meters. This well-known design is used (with impressive results) by many DXers, and it's an inexpensive and effective antenna that's not too big.

The modern triband Yagi was developed from a multifrequency dipole invented and perfected by Howard K. Morgan, Superintendent of Communications, Transcontinental and Western Airline, Inc. The requirement of the airline (the grandfather of the modern TWA) was for a simple, multifrequency antenna that would provide good reception of various aircraft frequencies at ground communication stations. The multifrequency dipole devised by Morgan was described in the August, 1940, issue of *Electronics*, and the original drawing from that article appears in **fig. 1**.

The Morgan antenna consisted of a center-fed dipole with the end insulators replaced by parallel-tuned circuits. Extra wire sections were added beyond the circuits so that the dipole was again resonant at a lower frequency.

For example, if the center dipole section is cut for 21.2 MHz and the parallel-tuned circuits (commonly called *traps*) are tuned to 21.2 MHz, the dipole works in a normal manner; the very high impedance of the resosulator. Wires that have been added after the traps have little, if any, effect on antenna operation at, or near, 21.2 MHz.

If wire sections are added after the traps are cut to the proper length, the overall antenna system will resonate at a lower frequency, say, 14.0 MHz. The presence of the tuned circuits affects the length of the antenna, so resonance is obtained at 14.0 MHz with an overall antenna length somewhat shorter than normal. A typical antenna is shown in **fig. 2C**. The traps act as electrical switches that are either open or closed, depending on the frequency of operation of the antenna.

Morgan's article pointed out that antennas for operation on as many as four different frequencies had been built successfully. Finally, the article

provided detailed information concerning adjustment of the traps for proper antenna operation.

resurrection of the multiband dipole

Morgan's multifrequency antenna died a quick death. Here was the perfect antenna for operation on the various Amateur high-frequency bands; the traps were easy to build and adjust, low-impedance transmission line was readily available, yet nobody carried the idea forward. With the coming of World War II and the ban on Amateur Radio, the multiband-antenna principle fell by the wayside.

It was not until after the war that the concept of multiband operation surfaced again, in a design by Chester Buchanan, W3DZZ, described in the December, 1950, issue of *Radio and Television News*. Buchanan described a dual-band beam for 10 and 20 meters using trapped elements. He also provided the first complete description of how the trapped antenna worked. His final beam design, known to many DXers as the "W3DZZ beam," was fully described in *QST*, for March, 1955.

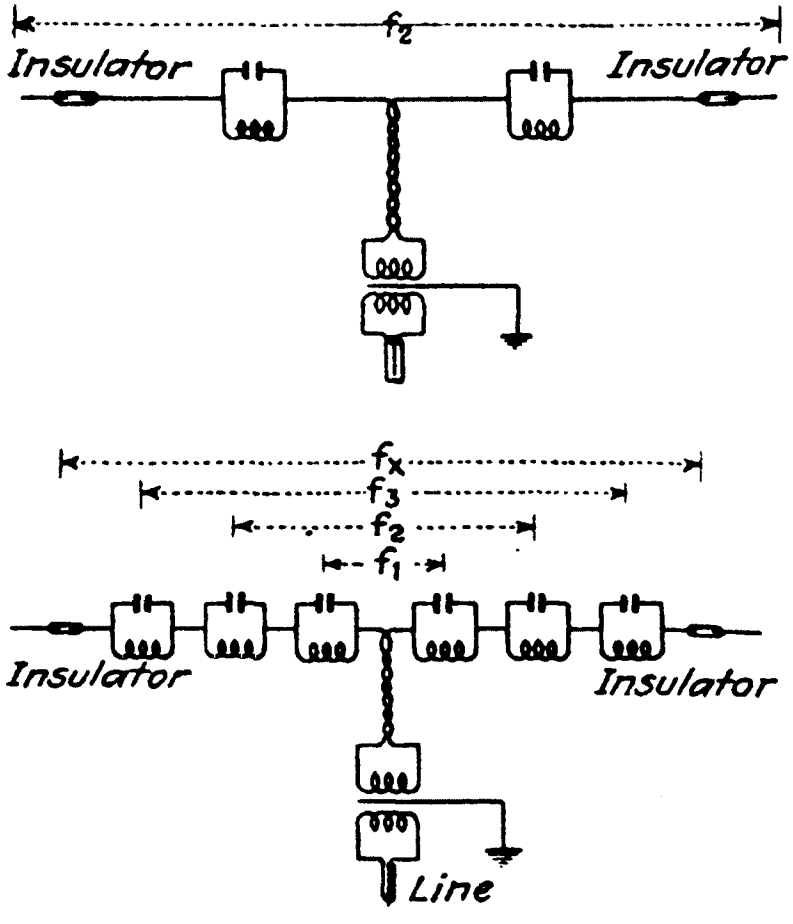


fig. 1. The original illustration in the issue of *Electronics* magazine depicting the trap dipole scheme evolved by Howard K. Morgan. The multifrequency antenna was originally designed for ground-station reception in the aeronautical service. Parallel-tuned trap circuits served as insulators at the resonant frequency of trap and antenna.

how the triband beam operates

Frequency-sensitive "switches" are the operating secret of the triband beam. The switches consist of a capacitor and inductance connected in parallel. This is a simple parallel-tuned circuit, which provides a very high impedance across the terminals at the resonant frequency.

The actual value of the impedance is the reactance of the coil times its Q, ($Q \times Q_L$). If the value of Q is high (Q being the electrical excellence of the coil), the circuit works as a high-impedance insulator at the circuit resonant frequency.

The curve in **fig. 2D** shows that the off-frequency reactance of the circuit is quite small: inductive at frequencies lower than resonance and capacitive at frequencies higher than resonance.

When the trap is placed in an antenna, the equivalent circuit of the antenna above and below resonance is shown in **fig. 2C**.

On 15 meters the center portion of the antenna works as a dipole with trap "insulators" tuned to 15 meters. When the antenna is used on 20 meters, the inductive reactance of the traps is quite low, and they act as loading coils. The wire length between the traps is cut so that the wire, plus the loading coils, is resonant at 20 meters, in conjunction with the center section.

Thus, on 20 meters, the trap dipole

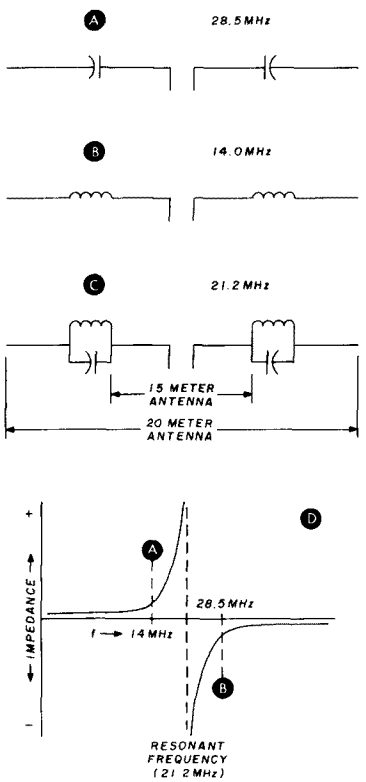


fig. 2. Operation of tuned trap for 20-15 meter, two-band dipole antenna. A: Equivalent circuit of antenna and trap at some frequency above resonant frequency of trap. Trap "looks like" a series capacitance. B: Circuit of antenna and trap at some frequency below resonant frequency *trap. Trap* "looks like" series inductance. C: At trap resonance, trap acts as a very high-impedance — the equivalent of an insulator. Examples given are for a trap tuned to 21.2 MHz (15 meters). D: Impedance chart of 15-meter trap showing reactance curve through the 14-28 MHz region. At 14 MHz the coil is the dominant component of the trap, and at 28.5 MHz the capacitor is the dominant component. Antenna is resonant at 14 MHz but is not resonant at 28.5 MHz. An extra set of traps is required for 10-meter operation, as shown in fig. 3.

is considerably shorter than normal due to a portion of the antenna being duplicated by the series inductance of the traps — the antenna is *nonresonant* on 10 meters unless extra traps are added.

To put it all together, in a triband element, the inner section and inner traps are resonant at 10 meters, the middle portion of the antenna and associated traps are resonant at 15 meters, and the whole antenna assembly is resonant at 20 meters (**fig. 3**).

trap performance

The trap is the heart of the triband antenna. A good trap will have reasonably high *Q* and must be waterproof. Many Amateurs make their own traps for triband dipoles[1] from an airwound inductance and a transmitting-type ceramic capacitor. The trap is placed in a waterproof housing.

Commercially made traps for triband beams are more sophisticated and are designed for mass production. The two traps in one section of an element may be combined into one structure, as shown in **fig. 4**. This arrangement provides a compact and rugged assembly.

No reliable information exists, as far as I know, as to the actual gain of a triband beam compared to a full-size antenna. Admittedly, the perfect trap has not yet been built, so some power is lost in each trap. In addition, on the two lowest bands, the antenna elements are not full size, so additional power is lost because of the reduced element length. This power is lost in the trap, which acts as a loading coil.

On the whole, the tribander design is good. The triband Yagi beams on the market *work*, and work well, judging from the number of DXers who use them and the robust signals they put out.

triband-beam bandwidth

One specification in which the triband beam suffers is bandwidth. On 10 meters, where the inner set of traps act as insulators, the bandwidth of the triband Yagi compares favorably with that of a conventional 10-meter Yagi beam. On 15 and 20 meters, operational bandwidth is somewhat restricted, because a portion of the element on each band is made up of the trap (or traps) for the higher-frequency band.

Then, too, some triband beams are built on shorter-than-normal booms to conserve space. This compromise further reduces operating bandwidth (and gain) — especially on 20 meters.

A set of representative SWR curves for a triband Yagi and a full size 20-meter Yagi is shown in **fig. 5**. Both beams are built on 20-foot (6-meter) booms. Observe that the 20-meter bandwidth of the tribander suffers in comparison with the full-size 20-meter beam, but bandwidth improves on 15 meters, and is equal for both antenna designs on 10 meters. This is of little consequence to the Amateur having a tube-type final-amplifier stage with an adjustable output network, but it poses a problem to those who have a solid-state output stage that requires an antenna with a low standing wave ratio.

One way around this problem is to build an SWR "flattener" that will reduce the SWR on the line at the transmitter end of the line (**fig. 6**). This simple matching network is placed between the coaxial line to the antenna and the station SWR meter. The capacitors and number of coil turns are adjusted for lowest SWR on the operating band. It can be easily adjusted for near-zero SWR at any point in the 10, 15, or 20-meter bands by tuning the controls for minimum SWR as observed on the meter. The settings can be logged for future use.

is a triband Yagi beam practical?

Based on personal observations over the years, the answer to this question is *yes*. If you have a well-made tribander, you have the tremendous advantage of three-band operation with one relatively small antenna. I've used a triband Yagi for years, alternating with a full-size 20-meter beam, on occasion. As far as working DX goes, I can do equally well with either antenna, and I notice no differ-

ence between the three-band design and the single-band beam.

Common sense and measurements made on the triband Yagi tell me that it isn't as efficient as the full-size beam. The bandwidth is somewhat restricted, and the front-to-back ratio isn't quite up to snuff, particularly on 15 and 10 meters. But these complaints fade away when I consider the convenience of working *three bands*, and the fact that I can compete in DX work and get reports that are just about equal to those of others in the area.

Tests. Before I installed the tribander, I wouldn't have believed this, as I took the traps into the company laboratory and measured the Q on a precision meter. A trap that I made out of the best materials available (air-wound, silver-plated, copper coil and a transmitting-type ceramic capacitor) provided a Q of over 300 at 30 MHz.

The Q of the commercial trap, measured at 30 MHz, was only about 180. This so discouraged me that the triband beam sat in my garage in the original box for about a year. Finally, deciding to see for myself how the antenna performed, the 20-meter Yagi came down, and the tribander went up in its place. Despite my misgivings, the triband worked, and worked well.

Some of my engineering colleagues sniffed in disdain at my unscientific test and were unmoved when I beat them out in a DX pileup. "Pure luck," was their conclusion.

Well, I don't know about that. Luck and operating skill surely are factors to be reckoned with. But if the antenna doesn't work, all the luck and operating skill in the world are to no avail.

Power transfer. It's true that some transmitting power is lost in the traps. I have a telescoping tower and can reach the traps in my antenna from the garage roof when the tower is retracted. Running a kilowatt input for 10 minutes, key down (when the band is dead!) results in the traps being slightly warm to the touch. Obviously, some rf power is being converted to heat in the traps. Other hams (having more ego than common sense) have attempted running excess power to a trap Yagi beam and have damaged the traps.

In conclusion, then, a good trap Yagi beam is an acceptable compromise for the Amateur who wants

table 1. Data for the G3LDO wire-beam antenna. All dimensions are in inches and are for insulated wire; multiply by 1.04 for uninsulated wire. Dimension C is approximate.

band	reflector	driven element	A	B	C	D
20	452	417	245	263	180	33
15	302	279	154	166	113	22
10	225	208	114	122	85	15

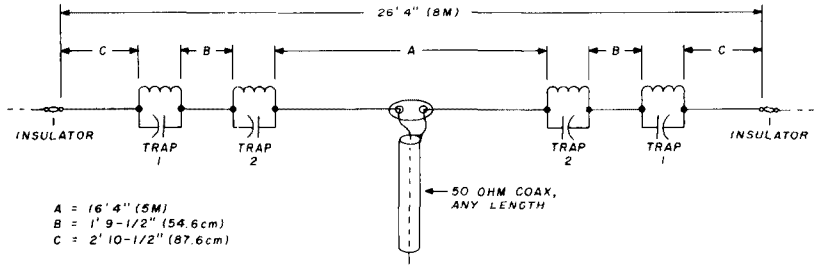


fig. 3. A triband element for 20, 15, and 10-meters. Dimensions are given for no. 16 (1.3mm) antenna wire size (not critical). Each trap is resonated to the design frequency before it is installed in the antenna. Length of each trap is about 2 inches (51 mm). Small ceramic or mica capacitors, rated at 3 kV, are used, which should have zero temperature coefficient.

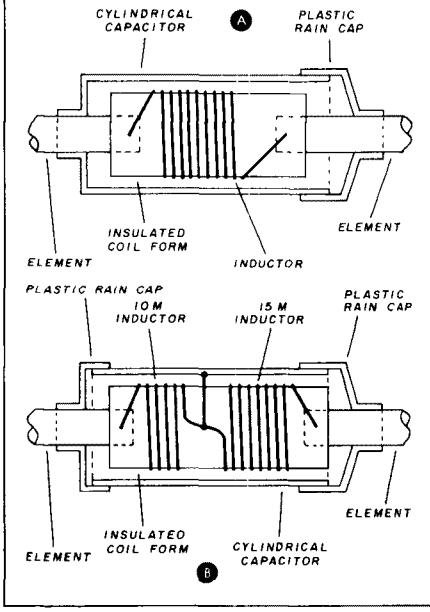


fig. 4. Typical trap construction. A: Single trap composed of inductor connected in parallel with cylindrical capacitor. The capacitor serves as an outer shield for the inductor and provides capacitance between cylinder and coil. End of assembly is sealed against weather with a plastic rain cap. B: Dual, two-band trap composed of two coils mounted within a single cylindrical capacitor. Number of turns on coils and placement within cylinder determines effective capacitance. Ends of assembly are sealed with plastic rain caps. Connection between coils and cylinder is made at center junction of inductors.

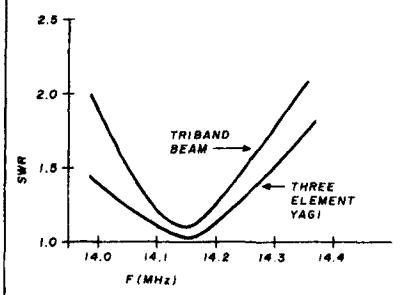


fig. 5. SWR bandwidth curve of typical triband Yagi beam is quite sharp on 20 meters, approaching 2 at band edges. A three-element, full-size Yagi exhibits a more moderate SWR curve for the same frequency span. On 15 meters, tribander bandwidth is somewhat improved and is essentially equal to full-size Yagi on the 10-meter band.

three-band operation. If a solid-state transmitter is used, an SWR "flattener" will prove helpful in making the transmitter perform at top efficiency.

the G3LDO wire

While on the subject of Yagi antennas, the interesting design by G3LDO is worth considering.[2] Experiments were run on 144 MHz with wire beams, and G3LDO came up with the interesting observation that the resonant length of a wire element depended upon the insulation on the wire. Uninsulated copper wire and enamel-coated copper wire provided "normal" dimensions, whereas insulated copper wire (hookup wire) had a velocity factor of about 0.965. The insulation on the tested wire was PVC (polyvinyl chloride).

Based on this information, G3LDO built a test beam on 2 meters, and then a larger model for 10 meters (fig. 7). He found that bending the elements back in the plane of the antenna caused an increase in the resonant frequency of the bent element and also resulted in a drop in gain. The solution was to fold the elements back in umbrella fashion, with the ends of the elements forming guys for the bamboo or fiberglass support structure. Dimensions for the beam are given in table 1. The performance of this simple and inexpensive wire beam was equal in every way to a standard equivalent design using full-size elements. This looks like a good antenna design for the ham who has a problem locating aluminum tubing.

a TVI filter for the 6-meter operator

Do you have a problem with 6-meter operation? It's a tough deal, what with TV channel 2 only a few megahertz away. Filters that can protect channels 2 and 3 (and provide attenuation of TV garbage in the 6-meter receiver) are hard to find.

My attention has just been directed to a new filter that will be of interest to all 6-meter operators. It is the *Unadilla/Reyco* Interfilter, specifically designed for 6 meters. It's rated for full Amateur power over the range 50-52 MHz and provides over 63 dB attenuation at TV channel 3. (Attenuation at channel 2 is somewhat less.) For full information on this interesting filter, write Unadilla/Reyco, 6743 Kinne St., East Syracuse, New York 13057.

references

1. Design and construction of trap antennas is covered in detail in *Simple Low-cost Wire Antennas,* by the author of this column. Available from Ham Radio's Bookstore for $6.95.
2. This material is abstracted from *Radio Communications,* a publication of the Radio Society of Great Britain, 35 Doughty Street, London WC1N 2AE, England.

ham radio

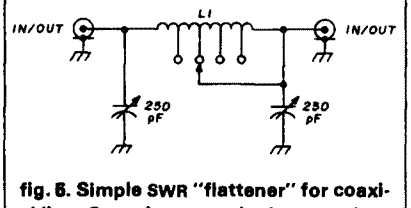


fig. 6. Simple SWR "flattener" for coaxial line. Capacitors are single-spaced receiving types for powers to 200 watts. Mica compression units can be used for low power. Inductor consists of 15 turns, 1-inch (25.4mm) diameter and 2 inches (51mm) long. Tap to coil is through a ceramic, single-pole rotary switch, such as Centralab 2501 (two to six positions, nonshorting). The coil is tapped about every other turn. Wire tap can easily be soldered to coil by depressing turn on either side of tap with screwdriver to allow tap wire to pass around a turn of the coil (coil may be a B&W miniductor or equivalent). Network is symmetrical; either terminal may ba used for input or output.

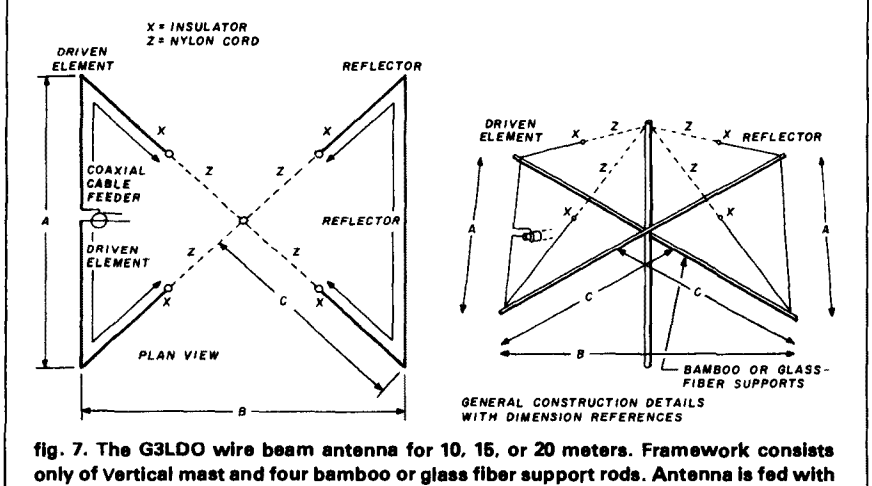
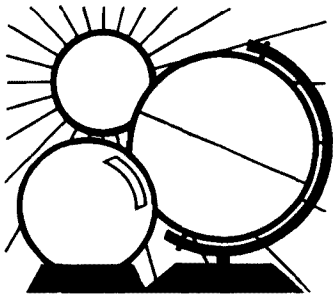


fig. 7. The G3LDO wire beam antenna for 10, 15, or 20 meters. Framework consists only of vertical mast and four bamboo or glass fiber support rods. Antenna is fed with coaxial line at midsection of driven element. Dimensions are given in table 1.



DX FORECASTER

Introducing Garth Stonehocker, KØRYW, who will present a series of columns on propagation and DX forecasting. Garth is a physicist and electronics engineer with extensive experience in propagation forecasting. He was associated with the Central Radio Propagation Laboratory and also did short-term radio propagation forecasting for the North Atlantic Warning Service in Boulder, Colorado.
First licensed in 1950 as W4RCF, then as W7ROY, Garth has been a member of several DXpeditions in conjunction with propagation forecast studies. Among them were an expedition to Antarctica (KC4USK) in 1956-58 and to the Cook Islands (KH6MG/ZK1) in 1958. Garth is a DXer and enjoys recording DX signals from beacons for propagation studies. Editor

New DXers

Are you a new ham who has come onto the thrill of your first DX with that new rig for Christmas, or an old *one* that has taken time out from years of rag chewing for a renewed go at DX chasing? If either, you may be interested in some propagation fundamentals and a look at which frequencies to use for putting the signal where you want it. To get your signal there the loudest of the bunch and to receive his probably weaker signal (other countries usually have lower power limits) is the goal. This can be done by fine-tuning your system for the particular location of the DX of your interest. That is, the antenna and ionosphere can be coupled together to increase the chance of their hearing you, and you hearing them, by the signal going to the right azimuth and out to the right distance.

The height of "reflection" in the ionosphere depends on the frequency band used. The angle of incidence into the ionospneric layer also affects what depth in the ionosphere the radio wave penetrates to be "reflected." Your antenna system needs to feed the maximum power at the correct vertical take-off angle to be maximum at the correct distance away and the correct azimuth for the correct direction (great circle bearing, usually). This is the best coupling to the ionosphere. The distances mentioned in the band-by-band summary show how the frequency penetration into the ionosphere varies the signal distance from band to band. A different antenna should be used for best results in short skip and in long skip; a high take-off angle for short skip and a lower angle for long skip. Articles on antennas often mention the take-off angles, or you can consult the antenna handbooks.

January is very similar to December in propagation effects. The ionosphere is a balanced energy system that changes slowly in its seasonal change from month to month. There is an intense but short meteor shower over a few hours sometime between January 2nd through 4th. It is known as the Quadrantid shower.

Band-by-band summary

Six meters will open occasionally for F2 long skip propagation with hops 1,000-2,500 miles long and with many hops usable. The openings will follow the sun during the day and early evening.

Ten and Fifteen meters will have openings similar to 6 meters, but more often and longer. Worldwide DX is usual from after sunrise until well after sunset during peirods of 27-day solar flux maxima. Short skip of 1,200 miles maximum distance is also possible and will also be following the sun across the earth.

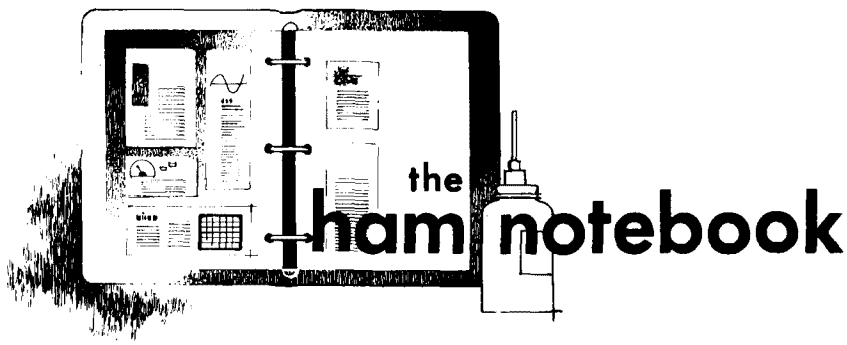
Twenty meters will be open most all days and nights to some area of the globe, with long skip and plenty of short skip with similar distances and number of hops as the 15, 10, and 6 meter bands. This is the workhorse of the bands. Tall towers and high beams or quads are a natural for long skip for this band.

Forty and Eighty meters will be the most usable night-hour bands for DX. Most areas of the world can be worked between darkness until just before sunrise. Hops shorten on these bands to about 2,000 miles for 40 and 1,500 miles for 80 meters, but the number of hops can increase, since signal absorption in the ionospheric D region is low during the night. The path direction follows the darkness across the earth, similar to the higher bands following the sun. Daytime short skip can be used during the day and night, particularly if low-height horizontal antennas (high take-off angle) are used. Vertical antennas over good ground systems give the lowest take-off angles for long skip on these bands.

One-Sixty meters will be about like eighty meters and provide good stuff for the enthusiastic DXer who can come up with low-take-off angle antennas with good efficiency at the long wavelength of this band.

ham radio

GMT	PST	WESTERN USA N	NE	E	SE	S	SW	W	NW	MST	MID USA N	NE	E	SE	S	SW	W	NW	CST	EST	EASTERN USA N	NE	E	SE	S	SW	W	NW
0000	[illegible]	10	—	15*	10	15	10	10	10	[illegible]	10	40	15	10	15	10	10	10	[illegible]	[illegible]	15*	20	15	15*	20*	10	10	10
0100	[illegible]	10	—	20	10	15	10	10	10	[illegible]	10	40	20*	15	15	10	10	10	[illegible]	[illegible]	15	20	20*	15	20*	10	15*	15
0200	[illegible]	10	—	20	10	20*	10	10	10	[illegible]	15	20	20	15	15	10	15*	15*	[illegible]	[illegible]	15	40*	20	15	20*	15*	15	15
0300	[illegible]	10	—	20	15	20*	10	10	15*	[illegible]	15	20	20	15	20*	10	15	20*	[illegible]	[illegible]	15	40	20	15	20	20*	15	15
0400	[illegible]	15	40	20	15	20*	10	10	20*	[illegible]	20	40*	20	15	20	15*	—	20	[illegible]	[illegible]	20	40	20	15	20	20	15	20*
0500	[illegible]	15	40	20	15	20	15	15*	20	[illegible]	—	40*	20	15	20	15	—	20	[illegible]	[illegible]	20	40	20	15	20	20	20*	20
0600	[illegible]	20	40	20	20*	20	15	15	20	[illegible]	—	40	20	20*	20	15	—	20	[illegible]	1:00	—	40	20	15	20	20	20	20
0700	[illegible]	—	40	—	20	20	15	15	—	[illegible]	—	40	—	20	20	15	—	20	1:00	2:00	—	40	—	20*	20	20	—	—
0800	[illegible]	—	20	—	20	20	20	20*	—	1:00	—	40*	—	40	20	20*	—	20	2:00	3:00	—	—	—	20	20	20	—	20
0000	1:00	—	20	—	20	20	20	—	—	2:00	—	40	—	40	20	20	—	—	3:00	4:00	—	—	—	20	20	20	20	—
1000	2:00	—	20	—	40	20	20	—	40	3:00	—	—	—	40	20	20	—	—	4:00	5:00	—	40	—	40	20	20	20	—
1100	3:00	—	—	—	40	20	20	—	40	4:00	—	—	—	20	20	20	—	—	5:00	6:00	—	20*	—	40	20	40	—	—
1200	4:00	—	—	20	—	40	40*	—	40	5:00	—	—	20*	20*	20	20	—	—	6:00	7:00	20	15	15*	40	20	40	40	—
1300	5:00	—	20	15	20	20	40	20	40	6:00	—	20	15	15	20	40*	—	—	7:00	8:00	20	10	10	15	—	40	20*	20
1400	6:00	—	20	15	20	—	40	40*	40	7:00	20	15	15*	10	—	20	20	40	8:00	9:00	20	10	10	10	—	80*	15	—
1500	7:00	—	15	15*	20*	—	40*	40*	40	8:00	20	15*	10	10	—	20	20*	40	9:00	10:00	20	10	10	10	—	40	15	—
1600	8:00	20	15*	10	10	20	20	20	40*	9:00	20	10	10	10	—	15	15	20	10:00	11:00	20	10	10	10	—	40	10	—
1700	9:00	20	15	10	10	—	15	15	40	10:00	20	10	10	10	—	15	10	20	11:00	12:00	20	15*	10	10	—	20	10	—
1800	10:00	20	15	10	10	—	15*	15	40	11:00	20	15*	10	10	—	15	10	—	12:00	[illegible]	—	15*	10	10	—	15	—	—
1900	11:00	20	20	10	10	—	10	15	40	12:00	—	15	10	10	—	10	10	—	[illegible]	[illegible]	—	20	10	10	—	10	—	—
2000	12:00	40	20	10	10	—	10	15*	20	[illegible]	—	20	10	10	—	10	10	—	[illegible]	[illegible]	—	20	15*	10	—	10	10	—
2100	[illegible]	40*	20	15	10	—	10	10	15	[illegible]	—	20	15*	10	—	10	10	20	[illegible]	[illegible]	—	20	15	10	—	10	10	20
2200	[illegible]	20	20	15	10	—	10	10	10	[illegible]	20	20	15	10	—	10	10	15	[illegible]	[illegible]	20	20	15	10	20	10	10	15
2300	[illegible]	15	—	15	10	—	10	10	10	[illegible]	15	40*	15	15	—	10	10	10	[illegible]	[illegible]	15	20	15	10	20*	10	10	10
	JANUARY	ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN		ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN			ASIA FAR EAST	EUROPE	S. AFRICA	CARIBBEAN S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN



how accurate is that SWR meter?

A friend recently contracted a radio operator's most dreaded ailment: reflectophobia, the unwarranted fear of reflected waves on a transmission line. Fortunately, this was not a terminal case. I still remember the early morning phone call and the troubled voice saying, "Something is wrong with my antenna. The SWR won't go below 1.8." To make a long story as short as possible, there was nothing wrong with the antenna. The SWR meter he was using wouldn't read below 1.8. This made me think about SWR meters and their accuracy. Is there a way to check the accuracy of an SWR meter without using expensive or complicated test equipment? There is.

Basic transmission line theory tells us the SWR on the line will be the ratio of the load resistance to the line impedance.[1] If the load resistance equals the line impedance, the SWR will be 1:1. However, if the load resistance is either double or half the line impedance, the SWR will be 2:1. This is the key to a simple way to check the accuracy of an SWR meter. While it would be possible to use a 100-ohm resistor as a dummy load and measure the SWR, this method has several limitations. If the resistor has a 10 per cent tolerance, its resistance could be anywhere between 90 and 110 ohms; and it might not provide an SWR of 2:1. Additionally, carbon composition resistors can't dissipate more than a few watts, and anything but a QRP rig would overheat the 100-ohm dummy load. Using a wirewound resistor to increase the amount of power the dummy load can handle won't work because at higher frequencies the inductance of the wire in the resistor will have enough inductive reactance that the SWR won't be 2:1. Instead of using a 100-ohm dummy load with a 50-ohm transmission line to obtain an SWR of 2:1, we can use a 25-ohm dummy load and obtain the same results.

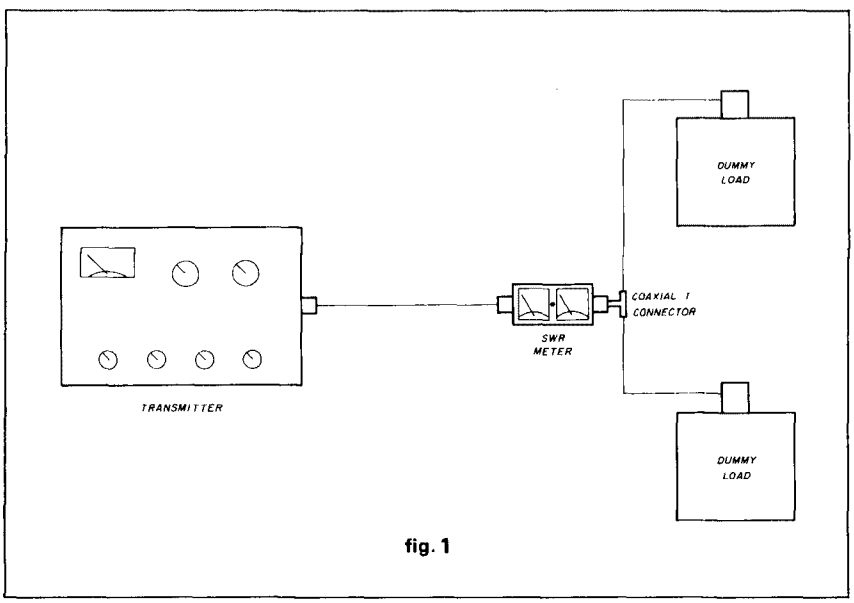


fig. 1

But where can I get a 25-ohm dummy load? It's easy. Just connect two 50-ohm dummy loads in parallel. Several commercially available dummy loads consist of a 50-ohm noninductive resistor in a bucket of transformer oil. The resistor itself can dissipate some power and the oil absorbs the heat, effectively increasing the amount of power the dummy load can safely handle.

Basic theory tells us the total resistance of two resistors in parallel[2] is $R = \frac{R1 \times R2}{R1 + R2}$. In this case, both resistors are 50 ohms; thus $R = 25$ *ohms*. Since $SWR = \frac{Z\,line}{Z\,load}$, then $\frac{50}{25} = 2.1$. The easiest way to connect two dummy loads in parallel is to use a coaxial T fitting (Amphenol 83-1T or equivalent) with short patch cords as shown in **fig. 1**. With two dummy loads in parallel, the load will

be 25 ohms and the SWR will be 2:1. If you are using a bidirectional wattmeter, the reflected power should be 11.11 per cent of the forward power. That's really all there is to it. This method of checking the accuracy of the meter can be used for hf, vhf, QRP, or even CB. In fact, any frequency and power level within the meter's capabilities can be used.

Now for the bad news. If your meter doesn't indicate an SWR of 2:1 when connected between a 50-ohm transmitter and a 25-ohm load, there might not be much you can do about it. Many lower priced SWR meters don't have any internal adjustments for calibration. Check the schematic for your meter to see whether it has a calibration adjustment. Even if your meter doesn't have a calibration adjustment, at least you'll know whether it reads high or low.

references

1. *Understanding Amateur Radio*, ARRL, 1977, page 96.
2. *Understanding Amateur Radio*, ARRL, 1977, page 9.

John W. Frank, WB9TQG

aligning Yagi beam elements

Assembling beam elements so that they are both in line with each other and parallel to the ground can be a frustrating experience when the eyeball or ground-assembly methods are used. The scheme shown in fig. 2 is effective in providing a neat installation in a few minutes, and doesn't require any special tools other than a small level.

Roy Lehner, WA2SON

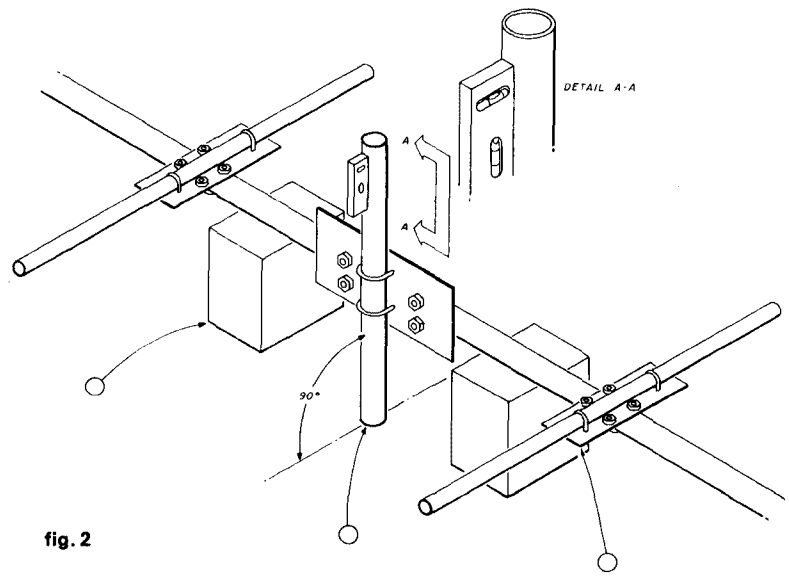


fig. 2

Drake R-4C receiver audio improvement

In the December, 1977, issue of *ham radio*, the article "Present-Day Receivers — Some Problems and Cures" suggests a 0.0015-μF capacitor be placed across R83 to correct a phase error in the Drake R-4C receiver.

I made this change and noted an improvement in audio quality. However, I also found another problem. With a headset connected to the earphone jack and the receiver in a standby position, an annoying shotgun noise was heard while transmitting. This noise was not noticed when the earphones were removed and the speaker alone was working.

A quick check of the R-4C circuit indicated that a 0.01-μF bypass capacitor was connected from the speaker terminal to ground. This effectively bypassed any rf picked up by the speaker leads. However, when the headset is plugged in, this bypass capacitor is disconnected from the circuit. The addition of a 0.01-μF capacitor from earphone jack to ground bypassed any rf picked up by the headset leads, and the problem was solved. Another solution is to remove the present 0.01-μF capacitor and reconnect it so it appears across both the earphone and speaker leads to the output transformer.

Bernard White, W3CVS

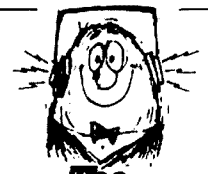
75S-3 alignment

During a recent rf circuit alignment procedure on my Collins 75S-3 receiver, I found a slight alteration that proved to be very beneficial to the reception of 10-meter signals. The modified procedure has been repeated a number of times with equal results.

The rf alignment procedure in the instruction manual is followed from steps a through **f**. After step **f**, repeak the OSC, RF, and ANT slug adjustments on the moveable platform; only a minor readjustment will be necessary. Once this is accomplished, continue with steps g through **o**. Then recheck the RF and ANT trimmer capacitor adjustments at 3.7 MHz. Again, a slight readjustment will suffice.

The foregoing should result in a marked improvement in the reception of 10-meter signals.

Paul K. Pagel, N1FB



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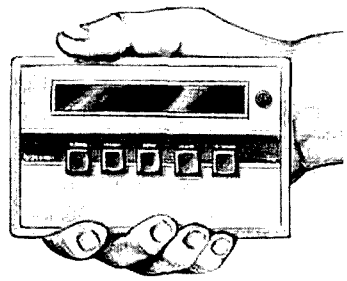
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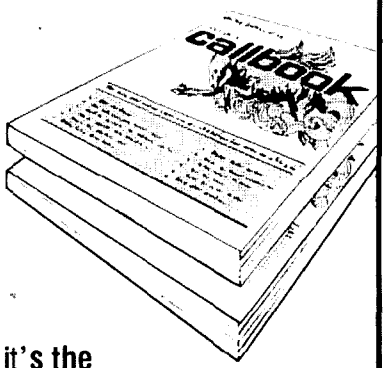
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MICHIGAN: Oak Park Amateur Radio Club's Swap and Shop, Sunday, January 11, 1981 at Oak Park High School, Oak Park Blvd., Oak Park, Michigan. 8 AM to 3 PM. Admission: $2.00 with under twelve free. League table, door prizes, YL raffle and table. Refreshments. Talk-in on 146.04/64 and 146.52 simplex. For info and reservations, SASE to: Rob Numerick, WB8ZPN, 23737 Couzens, Hazel Park, MI 48030 or (313) 398-3189.

OPERATING EVENTS

JANUARY 17th - 19th: QRP Amateur Radio Club International Inc.'s annual SSB QSO Party. Certificate awards to highest scoring station in each state, province, or country with more than two entries. More info: QRP ARCI Contest Chairman, Edwin R. Lappl, WD4LOO, 203 Lynn Dr., Carrboro, NC 27510.

JANUARY 17th and 18th: The Ford Tin Lizzy Club's North Metro Chapter's 3rd annual "Freeze Your Arctic Off" expedition from 2000Z the 17th to 1500Z the 18th. Handsome certificate available. More info: Box 545, Sterling Heights, Michigan 48078.

JANUARY 17th and 18th: Sponsored by West Virginia State Amateur Radio Council from 1700Z the 17th to 1700Z the 18th. Single operator only. Operation may be on all bands and repeater contacts are allowed. More info: N8AH, 933 Glen Way, South Charleston, West Virginia 25309.

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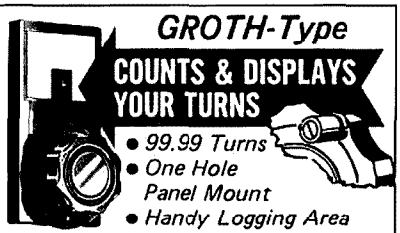
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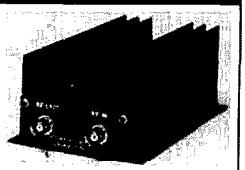
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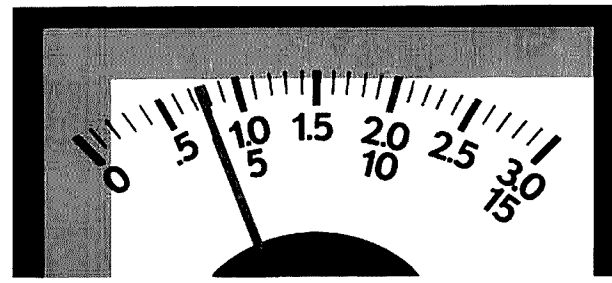
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magazine

FEBRUARY 1981

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- ham radio techniques 40
- repeater security 52



automatic noise-figure meter for preamplifiers and converters

ham radio magazine

incorporating HAM RADIO HORIZONS

FEBRUARY 1981

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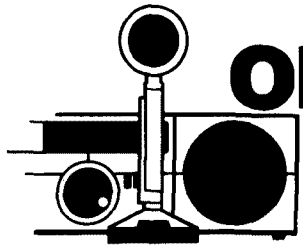
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Observation & Opinion

The urge to compete seems to be a part of human nature. Amateur Radio has its share of competition: DXCC, T-Hunts, Field Day. Competition stimulates people to improve, and that's healthy.

Another contest, which was popular years ago but which hasn't received much publicity recently, is the world high-speed CW championship. This is the challenge of challenges for operating skill: to break the record of Ted McElroy, ex-W1JYN, who made the *Guinness Book of World Records* by copying Morse code at a speed of 75.2 words per minute in a contest at Ashville, North Carolina, on July 2, 1939. Ted's record still stands. It's time for someone to try to break it.

Many readers will sniff in disdain at such a contest: "Who needs it?" "What will it prove?" I'm here to tell these people that Morse code is here to stay, like it or not.

Since I became editor of *ham radio*, I've received many letters from readers who scoff at the Morse code requirement in the Amateur license examination. For the most part, their reasons are that Morse isn't necessary for today's communications. I won't argue this point except to say that these people are somewhat misguided and know not whereof they speak. Listen to the parts of the Amateur bands devoted to traffic handling, the extra-class sub-bands, the Novice bands. It's CW, in whatever form.

A contest to break the world's record in Morse code reception is challenging, exciting, and in the best tradition of Amateur Radio for those who like to compete. Ted McElroy's record has been unbroken for 42 years. Who will be the next champ?

We at *ham radio* are proposing a contest for those who wish to try to break Ted's record. The contest will be conducted under official rules similar to those in effect during the contest in Ashville, North Carolina, in 1939. Appropriate prizes will be awarded to the winners.

Right now the contest is in the planning stage. The first contest will probably be held at one of the larger ham conventions in the spring of this year. We haven't yet decided which convention it will be. At any rate, the contest will be held under strictly controlled conditions, in a room devoid of distractions and noise. A contest of this sort must be done by the rules to guarantee fairness to all.

More information on the contest will be upcoming in future issues of both *ham radio* and *HR Report*. Look for it and plan to enter. CW is certainly not dead!

Our ex-*Horizons* readers will find some familiar topics in this issue: an equipment owner's questionnaire on three popular transceivers, Bill Orr's column on "Ham Radio Techniques," and of course Garth Stonehocker's "DX Forecaster." Next month we'll have the results of the Collins KWM2 and KWM2A equipment survey. Also look for the popular Q and A column and an interesting article by W7JWJ on the world's champion high-speed Morse code operator.

Alf Wilson, W6NIF
editor



comments

hyperbolic navigation

Dear HR:

Amateur Radio experts often reinvent the wheel in novel ways. A case in point is the article in *ham radio*, September, 1980, by Henry S. Keen, W5TRS, on "Navigational Aid for Small Boat Operators." The whole idea here is basically a hyperbolic navigation method and is markedly similar to the DECCA system used in Europe for many decades. DECCA operates on harmonic-related frequencies in the 75 kHz to 150 kHz range and uses exact integral divisors or multipliers as the intermediate beat frequency, very similar to Keen's idea of the second harmonic or subharmonic of the beat note. A problem that Keen has not addressed is that of "lane jumping," or resolution. At transmitter frequencies in the 10-meter range, the lane width between adjacent hyperbolas will be 5 meters, which taxes the resolution of the phase detector (and the steering navigator) for keeping track of which hyperbola the navigator is seeking.

At short ranges (a few miles), the use of the 1-watt-limit, 1750-meter experimenter band at 160 to 190 kHz might possibly make Keen's idea practical with lane widths of 1/2 wavelength or 875 meters for one cycle of phase change of the beat note. Thus 875 meters becomes 360 degrees of the phase detector output. Typical phase detectors resolve to 1 per cent or so at audio beat frequencies, so in practice 8.75-meter resolution of the path over a particular hyperbola might be resolved.

Another system is available from Hastings-Raydist Division of Teledyne Corporation. This has used transmitters in the 500 kHz to 2.5 MHz range, with hyperbolas 100 meters apart and resolution to within 1 meter. Still other worldwide hyperbolic navigation systems like OMEGA (10.2 to 13.6 kHz) and LORAN-C (100 kHz) use time-sequenced bursts or pulses to enable a large number of stations to all transmit on the same frequency and very effectively measure phase difference by the time of arrival or sequential memory-aided phase-locked loop methods. The very high power (1 megawatt) Navy vlf communications transmitters operating in the 14 kHz to 20 kHz range have also been used for worldwide navigation. Here, they are all atomic clock controlled, so all one has to do in principle is to convert the receiver measurement to a common i-f in the audio range at something like 100 Hz.

There are a great many pitfalls in devising new navigation systems that have been thoroughly worked over in the past 50 years. A general reference on the subject is Kayton and Fried *Avionics Navigation Systems*, John Wiley & Sons, published in 1969. Another reference, particularly on the early history of hyperbolic navigation, is NBS Monograph #129, "The Development of LORAN-C Navigation and Timing," U.S. Government Printing Office, $4.50, published October, 1972. A major problem with any CW-type hyperbolic system is that of proper lane identification; that is, how does the navigator know where to start the phase measurement, which lane or which line of position is he on? The SHORAN system that Keen mentions is not a CW hyperbolic method but rather a direct ranging time of arrival of pulse technique operating in the 200-300 MHz range. CW hyperbolic systems have largely been replaced by direct ranging ideas using coherent phase-locked transponders, but this always makes the system hardware more complex. When engineers think about these methods, what invariably happens is that the actual working hardware becomes much more complex and expensive than the inventor originally intended. Also, it is very hard these days to come up with something new. There are so many people thinking about the same idea at any given time that ten people will come up with the same idea at once, and there is just too much prior art to study.

Ralph W. Burhans
Athens, Ohio

RST

Dear HR:

I would like to make a comment to the "Observations & Comments," *ham radio*, September, 1980. I wholeheartedly agree with the idea of changing the RST system to something like Q1-Q2-Q3 as reporting signal conditions.

I am not a DXer or contest man, but I have put in some time logging on Field Day. It sure looks ridiculous to see the whole log with just RST 599. The RST system doesn't give a true picture of conditions. I like the Q1-Q2-Q3 because it seems to cover the total spectrum. But as it is done now, the whole contest report could be just all Q3s. Just for the record I think I will start using this system of Q1,2,3 and wait and see how many ask about it. It is worth a try.

George F. Schmidt, WØUCK
St. Louis, Missouri

presstop

PLAIN LANGUAGE AMATEUR RULES docket released in the form of a Notice of Proposed Rule Making, PR Docket 80-279, includes both the texts of the present Part 97 rules and the proposed rewrite, plus explanations. It was printed in the Federal Register of December 19.

Significant Changes, such as the deletion of all logging requirements and addition of a requirement that licensees must keep a copy of the Amateur rules on hand, also include a warning that the FCC can inspect a station "at any time during the business day or any time your station is transmitting or has just finished transmitting." The new rules no longer tell an Amateur how he should make various measurements, but only how the FCC inspector would make them during a station visit. The proposed new rules also clarify rules on interconnects (phone patches), antenna heights, and emergency and prohibited communications. They also include much more information on exams, both written and code, and propose that applicants with FCC Commercial CW licenses get credit for the equivalent Amateur CW exam. The rewrite also endeavors to consolidate and reorganize the rules into a more concise and logical arrangement.

In Addition To Being Printed in December 19's Federal Register, PR Docket 80-729 is also available in limited quantities from the FCC Office of Consumer Assistance, Room 258, 1919 M Street NW, Washington, D.C. 20554. Comments won't be due until June 19, 1981, and Reply Comments on August 19, 1981.

ITALIAN EARTHQUAKE AREA COMMUNICATIONS depended very heavily on Amateur Radio until telephone and other services were partially restored in mid December, with Amateur Radio still providing a major channel for relief traffic. Initial traffic from the disaster area included casualty lists, relayed from VHF links in the area by I8ULL near Naples. Many stations throughout the U.S. and Canada participated, with KA1BQ and WB2FID leading the action on 28802 mornings and 14240 later in the day when conditions permitted.

The Need For Transatlantic Relief communications links should continue for at least several more months, because of the extent of the damage (over 26,000 square kilometers devastated) and the magnitude of the U.S.-originated relief effort. KA1BQ (I8CZW) left for Italy last month to work on the scene and attempt to convince the Italian government to continue its third party OK.

I8ULL, Principal Terminal for U.S./Italy traffic, has been shut down several times by aftershock damage. KLM donated a replacement beam, which Alitalia shipped to Naples, to that station.

Participants In Relief communications represent all ethnic backgrounds, KA1BQ noted, a graphic demonstration of the fraternal character of the Amateur Radio service.

30-METER BAND OPERATION was begun in early December by VE3QB, using his Canadian commercial callsign, VE9LFZ, for preliminary one-way transmissions with partner VE9LIN (VE3BPD). They plan to operate daily at 1500, 1700, and 1900Z, plus random times evenings starting at 2200Z. CW and (later) ASCII will be the modes, using 10.101 and 10.149 MHz.

VE9LFZ Was Solid Copy on 10.101 MHz in the Midwest Thanksgiving afternoon, with a more than hour-long transmission that peaked as high as 5-6 even though Larry was running only 5 watts to an inverted V. These are test transmissions only, authorized by the Canadian government, and Amateur operations on this band will be illegal until January, 1982.

CALIFORNIA BRUSH FIRES, which destroyed about 350 homes and burned hundreds of thousands of acres in December, brought out plenty of volunteer Amateur Radio support. More than 30,000 acres burned east of El Toro, where more than 50 operators used W6TIO/R and simplex channels to provide Red Cross, paramedics, and fire headquarters with needed radio services. A link with the National Traffic System was also set up providing health-and-welfare communications for the fire fighters, who came in from a seven-state area.

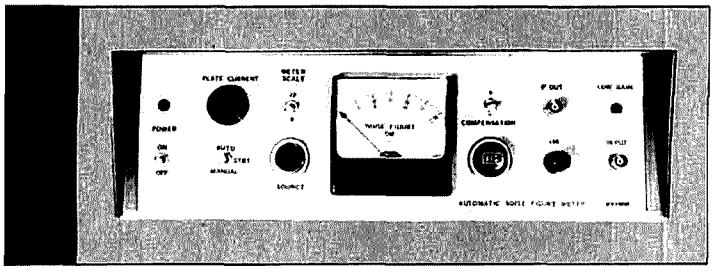
Another 150 Or So Amateurs served in San Bernardino/Riverside areas, where, along with many CBers, they provided communications for the Lake Arrowhead Evacuation Center.

Another Fire In The Big Basin Redwood State Park destroyed 350 acres of young redwoods there. Sixty-five-year-old K6TEH set up his portable 34-94 repeater there at the request of the Division of Forestry. A dozen others also took part.

PHASE III OF FCC'S CALLSIGN assignment system went into effect December 15, and with it all license classes except Novice became eligible to request callsign changes. Any Amateur who now holds a callsign not appropriate for his license class (1x3 for General/Technician, 2x2 for Advanced, 1x2/2x1 for Extra) may request a change to a callsign of the proper format, though without any choice as to the specific callsign he will receive.

FCC's New Form 610 (August, 1980 edition) is required by Phase III, so all previous editions are now obsolete and may not be used. As before, licensees still have the option of retaining their old callsigns when upgrading or changing call areas. A new callsign will not be assigned unless it's specifically requested by the licensee's having checked item 2F on the new Form 610.

Though Both The 4th and 6th call areas are running low on 2x1 callsigns for Extras, the Commission does not expect to be ready to go back to 1x2s until 1983 at the earliest.



automatic noise-figure meter

for preamplifiers and converters

A recent article by **W6NBI**[1] describes an easily duplicated temperature-limited diode noise generator and power supply. This generator provides both a reproducible source of noise and, by measuring the diode plate current, an easy method to measure the noise power output of the source. As will be discussed, verification of a receiver's noise figure by the use of this generator is straightforward, using either the y-factor or twice-power methods.

Optimization of the noise figure of a receiver is quite tedious because each time a parameter is varied, two measurements (insertion of a pad and some calculations) are required. Also, since the two measurements are taken at different times, any gain drift in the system will introduce error into the measurement. If you are willing to restrict the noise source to a temperature-limited diode, it's possible to build a very accurate automatic noise-filter meter that avoids some of the compromises multisource meters must make to accommodate different sources.

derivation of the noise-figure concept

Noise factor (F) of a receiver is defined as

$$F = \frac{S/N_I(\text{Ideal Receiver})}{S/N_A(\text{Actual Receiver})} = \frac{N_A}{N_I}$$

$$= \frac{\text{Noise Power Actual Receiver}}{\text{Noise Power Ideal Receiver}} \quad (1)$$

and in logarithmic terms

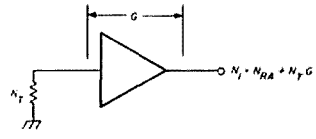
$$\text{Noise Figure } (NF) = 10 \log F \quad (2)$$

It's important to keep the *log NF* terms and the *numerical ratio F* terms separate in your mind; if you mix them up you'll make errors when calculating correction factors.

If we call N_I the noise output power from the receiver when its input is terminated in a 50-ohm resistor at a temperature of 290 K (62 F), then

$$N_I = N_{RA} + N_T G \quad (3)$$

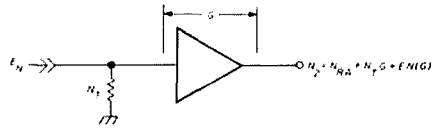
where N_{RA} = *receiver added noise power*
N_T = *termination resistor noise power*
G = *receiver gain*



If we then apply an excess noise to the receiver input we can define:

$$N_2 = N_{RA} + N_T G + (EN)G \quad (4)$$

where EN = *excess noise power.*



Noise power $(N) = kTB$

and k = *Boltzman's constant* 1.374×10^{-23} $\frac{\text{Joules}}{^\circ K}$

T = *absolute temperature* $^\circ K$ ($^\circ C + 273^\circ$)

B = *bandwidth*

then

$$N_T = k T_0 B \quad (5)$$

where T_0 = *290 K (62 F) (by IEEE Convention)*

$$EN = kTB \quad (6)$$

where T = *effective temperature of the excess noise source in* $^\circ K$.

The definition of the noise factor of a receiver (**eq. 1**) is

$$F = \frac{N_A}{N_I} = \frac{N_I}{kT_0BG}$$

By Edward T. Gisske, K9IMM, 7256 Mineral Point Road, Verona, Wisconsin 53593

The amount of noise added by the receiver is

$$\frac{N_2}{N_1} = \frac{kT_0BG + (F-1)(kT_0BG) + kTBG}{kT_0BG + (F-1)(kT_0BG)}^{*}$$
$$= \frac{FT_0 + T - T_0}{FT_0}$$

Rearranging

$$F = \left(\frac{T-T_0}{T_0}\right)\left(\frac{1}{\frac{N_2}{N_1} - 1}\right) \quad (7)$$

or, in dB

$$NF = 10 \log \left(\frac{T-T_0}{T_0}\right) - 10 \log \left(\frac{N_2}{N_1} - 1\right) \quad (8)$$

The first term is equal to the excess noise ratio (ENR) of the source expressed in dB

$$NF = ENR(dB) - 10 \log \left(\frac{N_2}{N_1} - 1\right) \quad (9)$$

The term N_2/N_1 is referred to as the y-factor and is used by automatic noise-figure meters such as the HP-340 series to measure noise figure in the following manner:[2]

With reference to **fig. 1**, note that the source is gated on and N_2 is measured; then the source is gated off and N_1 is measured. This sequence is repeated at about a 500-Hz repetition rate. The ENR of the source is known, and N_2 is used to set the gain of the i-f amplifier so that N_2 is a fixed output regardless of the receiver gain. Then, by measuring N_1, the ratio N_2/N_1 is known. The meter is calibrated to solve the equation:

$$NF = ENR - 10 \log \left(\frac{N_2}{N_1} - 1\right) \quad (10)$$

This ratiometric measurement factors receiver gain out of the measurement, so it's possible to tune for minimum noise figure without recalibration. Note that the i-f amplifier agc loop must be very tight, as the measurement depends on maintaining a constant reference (N_2) level. The i-f amplifier and detection circuitry must also be linear over a range of agc levels to get a valid N_1 measurement.

Another noise-figure measuring method, usually used for manual measurements, is called the twice-power method. This method forces $N_2 = 2N_1$ by adjustment of the source ENR.

$$NF = ENR(dB) - 10 \log \left(\frac{N_2}{N_1} - 1\right)$$
$$N_2 = 2N_1$$
$$= ENR - 10 \log \left(\frac{2}{1} - 1\right)$$
$$NF = ENR \quad (11)$$

Fig. 2 shows a block diagram of the measurement. In practice, the measurement is performed as follows: with the noise source off and the pad out of the circuit; the power meter reading is noted. The source is then activated and the 3-dB pad inserted into the circuit. The source ENR is adjusted to produce exactly the same reading as before. When this condition is satisfied, the ENR of the source is equivalent to the receiver noise figure. The ENR of the source is usually adjusted by padding the source with a precision variable attenuator.

The attenuator setting is subtracted from the known ENR of the source to compute the receiver noise figure. This works for temperature-limited diode, argon discharge, or semiconductor diode souces. With the temperature-limited diode, an additional method of adjusting source ENR is to adjust the diode plate current (by varying the filament current) and thus vary the effective source temperature. Coincidentally, in a 50-ohm system, the noise factor $F \cong \frac{diode\ plate\ current}{1000}$ and noise figure, $NF \cong 10 \log I(mA)$. (See reference 1 for a derivation of this relationship.) The advantage of the twice-power method over the y-factor method is that the power-measuring circuit is always operated at the same signal level; therefore linearity of the amplifiers and de-

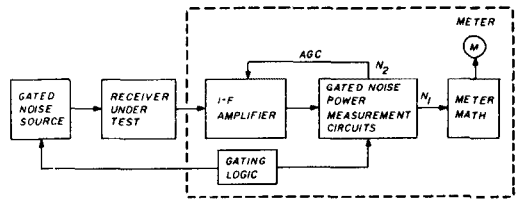


fig. 1. Simplified block diagram of the HP-340B Automatic Noise Figure Meter (copyright Hewlett-Packard Company, 1959. Used by permission). Commercial instruments such as this use the y-factor method of noise-figure measurement, where the y-factor is the ratio of N_2/N_1 (see eq. 10).

*The transition from **eq. 6** to **eq. 7** may not be obvious to some readers, in view of the appearance of the term $(F-1)$. The equation for N_2/N_1 is correct, however, as the following shows:

By definition, the noise temperature, T, of the input terminating resistor is related to the equivalent noise factor, F, contributed by the terminating resistor by the relationship

$$T = T_0(F-1)$$

rearranging

$$\frac{T}{T_0} = (F-1)$$

therefore

$$(F-1)(KT_0BG) = \frac{T}{T_0}(KT_0BG) = KTBG$$

Note that if $T = T_0$, $(F-1) = 1 \cdot (F-1)$ accounts for the noise power at the amplifier output due to the input terminating resistor operating at some temperature $T°K$. When $T \neq T_0$, then a correction for overall noise figure is made. **Editor.**

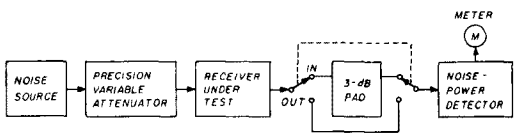


fig. 2. Block diagram of the twice-power method of manual noise-figure measurement. This method forces $N_2 = 2N_1$ by adjustment of the source excess noise ratio (ENR).

tector in the circuit *has* no effect on the accuracy of the measurement.

an automated twice-power measurement system

Commercial automatic-noise-figure (ANF) meters use the y-factor method because they're designed to work with a combination of sources, argon discharge, semiconductor or temperature-limited diode, necessary to cover a wide range of frequencies up to the GHz region. Frequencies of major interest to Amateurs are in the 10-600 MHz region. This allows the use of the temperature-limited diode as the only necessary source and greatly simplifies the measurement problem.

With reference to the block diagram of fig. 3 and the timing chart in **fig. 4**, note that the noise source is gated both in the filament circuit and in the plate circuit. The plate gate turns the source *on* or *off*, and the filament gate adjusts the ENR by pulse-width modulating the filament current. Because of its long thermal time constant, the filament is not used for noise source on-off gating.

The receiver under test can be any combination of amplifiers and/or mixers with an output frequency of 28 MHz and an output impedance of 50 ohms.

The ANF-meter input is through an electronically switched 50-ohm 3 dB attenuator. This pad is switched into the circuit when the source is on, and out of the circuit when it is off. A train of noise pulses from the attenuator is fed to the i-f amplifier, which amplifies the noise pulses to a usable level. The input level of this meter should be 7 μV (-90 dBm) or greater for proper operation.

The i-f strip output is detected with a half-wave hot carrier diode detector and fed through an amplifier to the two sample-and-hold (S&H) amplifiers. The S&H amplifiers are circuits that will follow the input voltage when in sample mode and hold the final voltage of the sample period in hold mode until updated with a new sample pulse. S&H 1 samples the last half of the *attenuator out-source off* period. Sampling is done in the last half of the period to allow attenuator and source switching transients to die out. S&H 2 samples the last half of the *source on-attenuator in* period. The outputs of these two S&H amplifiers are presented to the comparator. If the comparator decides S&H 1 output is higher than S&H 2, it turns on the source filament. If S&H 2 output is higher than S&H 1, it turns off the filament. This sample-and-compare cycle is repeated at a 170-Hz rate.

At this update rate, the filament thermal inertia will average the on and off pulses to give a filament temperature corresponding to exactly 3 dB ENR. The S&H 1 output is fed back to the agc input of the i-f strip to reduce the i-f gain for converters or amplifiers with very high gain or poor noise figure. This is a rather loose agc loop but, for this applicaton, where the sample-and-hold amplifiers are compared only to see which one is higher, it's only necessary to keep the i-f output within the common-mode range of the comparator and the linear range of the sample-and-hold amplifiers. The agc loop time constants and loop gain are somewhat critical because this is a sampled-data servo loop. Such loops, unless properly compensated, will tend to be unstable. Linearity of the system is unimportant, as the i-f amplifier, the detector and the S&H preamplifier are all working at the same level of noise when the system is in balance.

The source plate current is detected as a voltage across the 100-ohm resistor in the source plate supply return. As this current is being pulsed by the gating circuitry, S&H 3 is needed to sample during the *source on* period and hold during the *source off* period. S&H 3 output, which is proportional to the source plate current, is supplied to the log amplifier, which converts noise factor to noise figure and allows the meter to have a linear scale. The log amplifier output feeds a "perfect" rectifier, which ensures that only positive voltage reaches the meter. The summing junction of this op amp makes a handy place to supply a calibrated offset voltage to add or subtract a correction factor for the source ENR *vs.* frequency error and for loss pads.

manual noise figure measurement circuit

This meter can also be used for manual twice-power-method noise figure measurements when it is difficult to get a 28-MHz output from the receiver under test. In this mode the source is turned on all the time, and a comparator monitors a voltage corresponding to desired plate current (set by a front-panel pot) and the voltage across the meter. When the meter voltage is higher than the set-point voltage, the filament is turned off and *vice-versa*. When the source is adjusted to give exactly 3-dB ENR, the

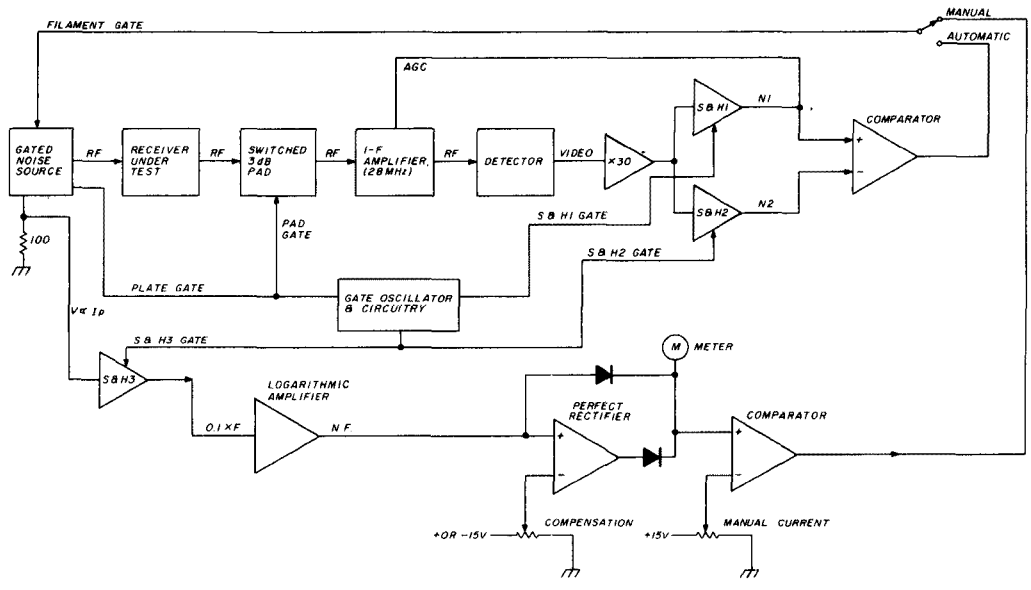


fig. 3. Automatic noise-figure measuring system using the twice-power method. System is designed for use in the 10-600 MHz region, which allows the use of a temperature-limited diode as the only necessary noise source, thus greatly simplifying the measurement problem.

noise figure can be read directly from the meter. The i-f loop is disabled during operation in manual mode.

circuit details

Fig. 5 shows the noise-figure meter schematic. The noise source can be either an HP-343A or the homebrew 5722 source described by W6NBI[1]. I prefer the 5722 source because the price for the tube is $9.00 compared to the $90.00 that HP charges for their noise diode. The homebrew source, if carefully constructed, should be as good as the HP source. The meter power supply is a fairly conventional ± 15V regulated supply. The 10-μF bypass capacitors for U13 and U14 should be mounted immediately at the device terminals or oscillation is a likely result.

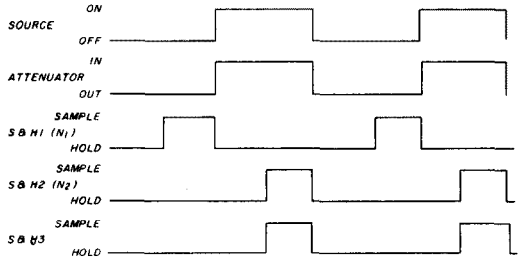
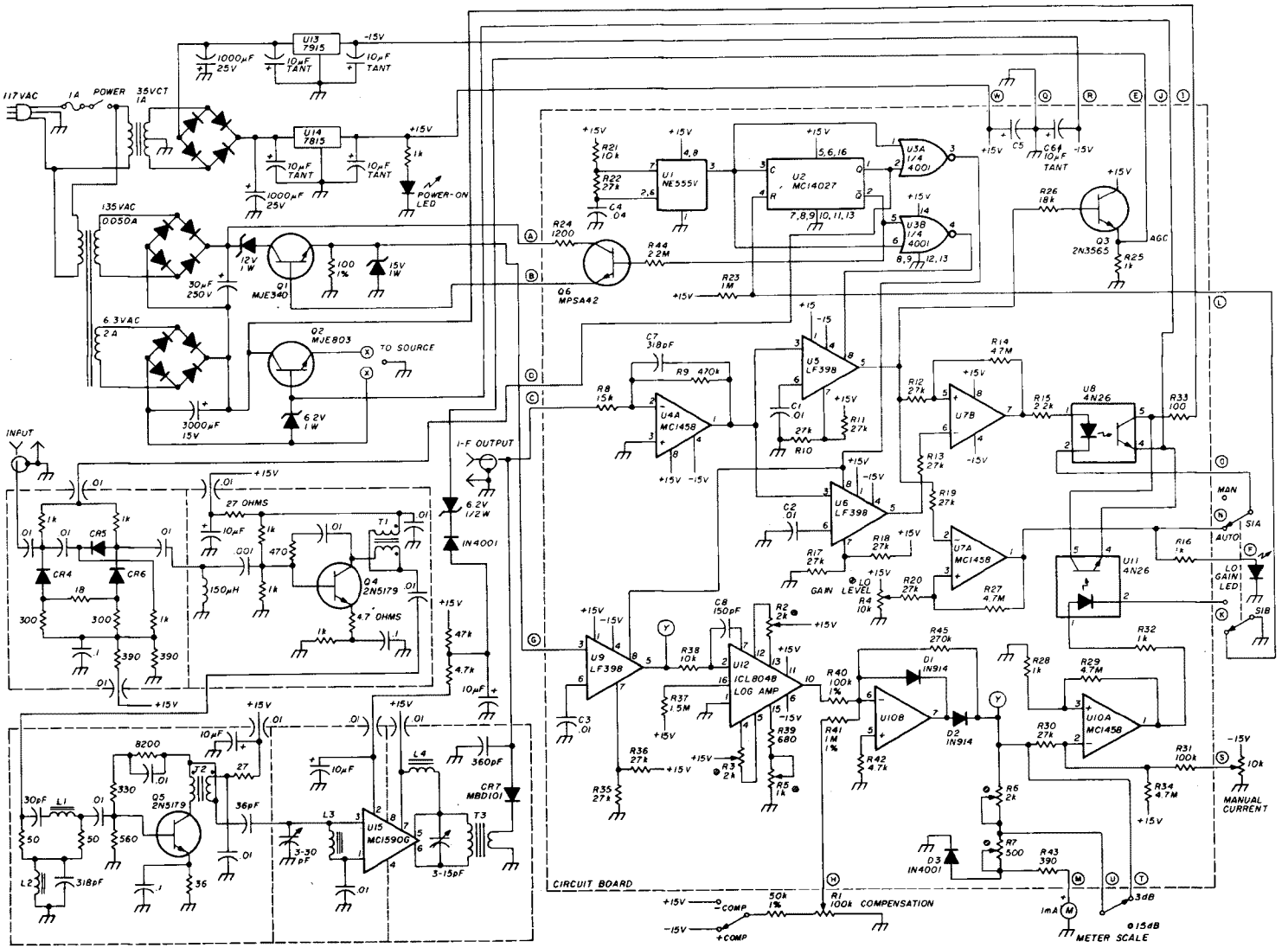


fig. 4. Timing chart for the twice-power noise-figure meter.

The source has a grounded plate, so the 200-volt plate supply has its positive end grounded through the gate transistor, Q1, and the current measuring 100-ohm resistor. Q1 and Q4 form a quasi-Darlington switch designed to minimize base current injection into the current-measuring circuit. The negative end of the plate supply is fed up the filament line to the source. Q2 gates the filament current, and the 6.2-volt zener diode ensures that the maximum filament voltage is 4.9 volts. Q2 is driven by opto-isolators, as it is floating 200 volts below ground.

The receiver noise output is applied to the electronically switched 3-dB pad at the input to the i-f strip. When the voltage at point D is + 15 volts, CR5 is turned on and CR4 and CR6 are back biased. This removes the pad from the circuit. When point D is grounded, the pad is switched into the circuit by CR4 and CR6, while CR5 is back biased. This pad should be symmetrically constructed using minimum lead lengths. The ultimate accuracy provided by the ANF meter depends on the accuracy of this pad. One-quarter-watt carbon film resistors and small disc ceramic capacitors should be used for best results. The output of the pad is connected to the next stage through a highpass filter to reduce the effect of switching transients on the next stage. Q4 is a broadband amplifier designed for 50-ohm input and output



C1,2,3 .01 µF polystyrene or polypropylene.
D4,5,6 Motorola MPN3402 PIN diode.
D7 Motorola MBD101 hot-carrier diode.
S1 Double pole double throw, center off, toggle switch.
U5,6,9 National LF 398 sample and hold amplifiers.
U12 Intersil ICL8048CCPE log amplifier.

L1 14t No. 22 T37-2 core
L2 3t No. 22 T37-2 core
L3 11t No. 22 T50-6 core
L4 12t No. 22 T37-61 core
T1,T2 6t No. 22 bifilar wound T37-61 core

fig. 5. Schematic of the automatic twice-power NF meter.

impedance and has 10 dB gain. A diplexer interstage network tuned to 28 MHz feeds another 11-dB broadband amplifier. The broadband negative feedback amplifiers are used to ensure unconditional stability and proper wideband termination for the pad.

U15, an MC 1590G, provides the bulk of the gain (50 dB) as well as a 60-dB agc range. Both input and output of this amplifier are tuned to 28 MHz; since it packs a lot of gain into a small package, shielding is necessary for stability. A hot-carrier diode coupled to the MC 1590 tank is the detector, and the 360-pF capacitor provides light filtering of the detected noise level. Averaging of the noise level is done by the memory capacitors in the sample-and-hold amplifiers. The detector output is coupled to U4A, which has a dc gain of 31 and provides some additional filtering.

N_1 and N_2 pulses are separated by the sample-and-hold amplifiers U5 and U6. Q3 buffers the output of U5. The 6.2 V zener diode and forward-biased silicon diode level-shift the agc for the MC 1590. The agc level starts at 6.8 volts and goes up with increasing signal level.

U7B compares N_1 and N_2 levels and decides whether or not to turn on the filament in the source. U7A is another comparator that decides if there is sufficient noise signal for an accurate measurement. If the N_1 pulse level is too low, the front panel "low gain" LED is lit, and the cathode of the LED in U8 is elevated to +15 volts. This action disables the filament circuit, keeping the terminating resistor cool and saving the noise tube.

U1, U2, and U3 compose the timing circuit for generating the gate signals. U1, an NE555V, functions as an astable multivibrator at 340 Hz. U2, a flip flop, divides U1's output by 2 and by combining U2 and U1 outputs in U3, the nonoverlapping quadrature sampling pulses are synthesized. In the manual mode, U2's reset input is held high. This action enables the source continuously and U9, the meter circuit sample-and-hold amplifier, operates at a 340 Hz rate. In the automatic mode U9 samples during the last half of the source-on period and supplies a smoothed voltage proportional to plate current to the log amplifier, U12. The signal at the output of U12 corresponds to noise factor × 0.1, which the log amplifier converts to noise figure. This chip is quite expensive (about $35) and can be eliminated if the meter is recalibrated. The meter will now read noise factor and should have 3 mA and 30 mA full-scale positions. If you decide not to use the log amplifier, pull U12 and disable U10B by removing its external components. Connect points Y together and do not install the compensation pot, R1, or its switch.

U10B, a perfect rectifier, blocks negative voltages from pinning the meter down-scale. U12 output is negative for source plate currents of less than 1 mA and −15 V for zero plate current. U10A is the comparator for the manual mode. It decides if the source current, as represented by a voltage across the meter circuit, is higher or lower than the desired current, set by the front panel manual-current control. The 4.7 megohm resistor between the output of U10A and its noninverting input supplies a minor amount of hysteresis, and the 4.7 megohm resistor between the inverting input of U10A and +15 V swamps out any offset in U10A and ensures that the plate current of the source can be zeroed with the manual current control.

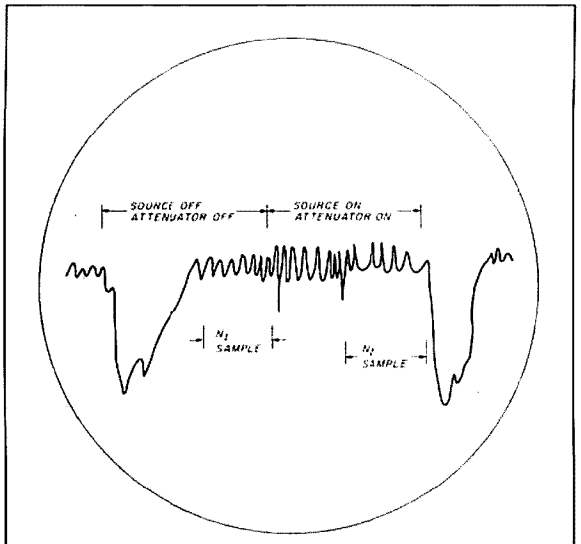
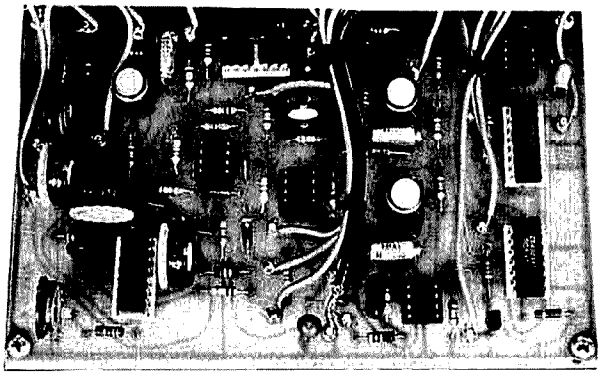


fig. 6. Sketch of oscilloscope pattern taken at the i-f output jack.



PC board.

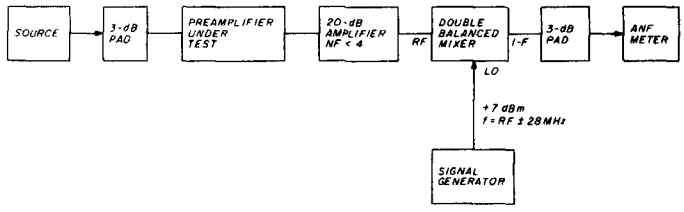


fig. 7. Block diagram showing technique for measuring noise figure of preamplifiers or converters.

construction

The i-f strip is built into an enclosure made of double-sided PC board. All voltages are brought into the strip through feedthrough capacitors. Button ceramic capacitors are used for bypass purposes, and ceramic standoffs are used for unbypassed tie points. Even though the i-f strip operates at 28 MHz, the F_T of Q4 and Q5 is 1.4 GHz, and the MC 1590 operates up to 300 MHz; therefore vhf construction techniques must be used to ensure stability. A shield should be mounted across pins 8 and 4 on the MC 1590 to isolate the input and the output of this stage.

The logic and analog circuits are all on the PC board. Sockets should be used for the integrated circuits as some must be pulled during calibration. All resistors are 1/4 watt 10 per cent tolerance, and all capacitors are disc ceramics unless otherwise noted. The power supply and switching transistors are mounted onto the chassis. Q2 should be bolted to the chassis for a heat sink. This transistor and the rest of the filament power circuit should be treated with caution, as it is at −200 volts.

Don't use a 2-pin connector for the source and rely on the connector shell for a ground; otherwise you may get a 200-volt surprise when you plug in the source with the power on. Use a 3-pin plug with the ground routed through a pin. U13 and U14 should be heat-sinked, and attention should be paid to the wiring of these ICs. Even though they are complementary ICs, the pinouts are different. The meter has a 1-mA 1000-ohm movement and is calibrated for 0-3 and 0-15 dB noise figure by erasing the original scale with an electric eraser and recalibrating with transfer letters. The compensation pot is a 10-turn linear digital readout pot with 10 volts applied across it. Either +10 or −10 volts can be used to give −10 dB to +10 dB compensation. This adjustment is used to null out the excess ENR of the source with increasing frequency and to compensate for loss pads between the source and the receiver.

checkout and alignment

First unplug all the ICs and confirm that the power supply voltages are correct. If they are, plug in U1, U2 and U3 and see if you get quadrature pulses out of U3A and U3B. Connect a 28-MHz signal generator to the input jack and an oscilloscope to point C. Increase the signal generator output until you see a train of pulses at point C. Peak the U15 input and output circuits. Reduce the signal level to some convenient value and verify that the levels of the pulse train are 3 dB apart. This must be done with a calibrated attenuator of known accuracy. Connect an rf pad (10 dB for example) between the signal generator and the input of the ANF meter. This standardizes the signal-generator output impedance to 50 ohms. Unplug U2 and connect point D to +15 V. Connect a DC voltmeter (preferably a digital voltmeter) to the i-f output jack and note the reading on the voltmeter. Then connect point D to ground and plug a 3-dB pad between the 10-dB pad and the ANF meter. The volt-

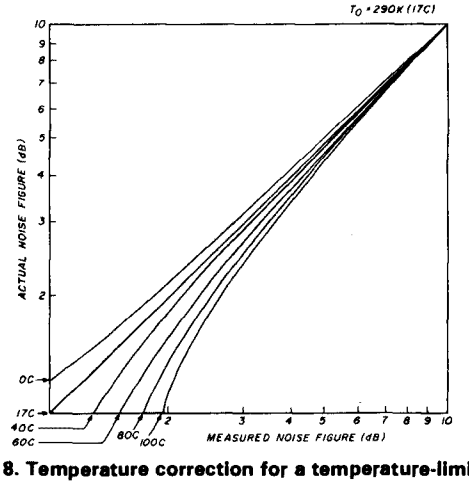


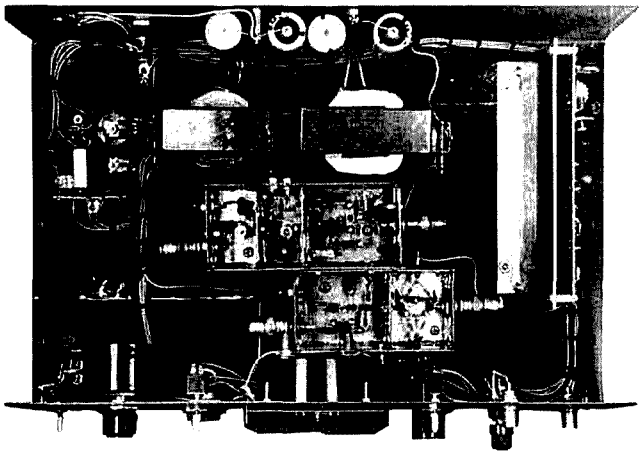
fig. 8. Temperature correction for a temperature-limited diode noise source (courtesy Hewlett-Packard Company).

meter level should remain the same. Disconnect the ground on point D and plug in U2. Plug in U4 and U5, and check to see if the pulse train is amplified by a factor of about 30 in U4A. Increase the signal level and see if the pulse train level at the i-f output jack stabilizes. This verifies that the agc loop is operational. Plug in U6 and U7. With the signal generator set for 7 μV and the pads removed, adjust R4 until the low gain LED just goes out. Turn the signal down and the LED should come on. Plug in U12 and temporarily solder a 10 k resistor between pins 2 and 7 of this IC. Ground pin 5 of U9 (make sure U9 is out of the socket), and adjust R3 for zero volts at U12 pin 7. Unsolder the 10 k resistor and unground U9 pin 5.

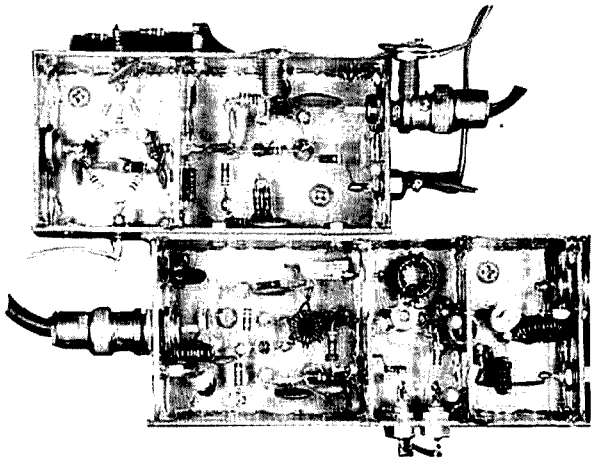
Connect an accurate source of 0.1 volt to U9 pin 5 (make sure U9 is still out of its socket) and adjust R2 for zero volts at pin 10 U12. Now turn up the source to +10 volts and adjust R5 for exactly −2.0 volts at pin 10 U12. Plug in U10, turn the compensation pot to zero, and adjust the voltage source to +0.2 volts at U9 pin 5. With the meter switch in the 3-dB position, adjust R7 for full scale. Change the meter switch to 15 dB, increase the source voltage to +3.16 volts, and adjust R6 for full scale.

Disconnect the voltage source and plug in the remainder of the ICs. Turn the AUTO STBY MAN switch to manual and plug in the noise source. The manual current control should vary the plate current (as expressed in NF) from zero up to 12 or 14 dB before saturating. Flip the switch to automatic and verify that the filament remains dark.

Connect the output of an amplifier to the input jack and apply power to the amplifier. The filament should light and the low-gain LED should extinguish. The meter should swing to saturation (12-14 dB). Now connect the source to the amplifier. Assuming the noise figure of the amplifier is in the range of the instrument, the meter should now indicate its noise figure.



Chassis layout.



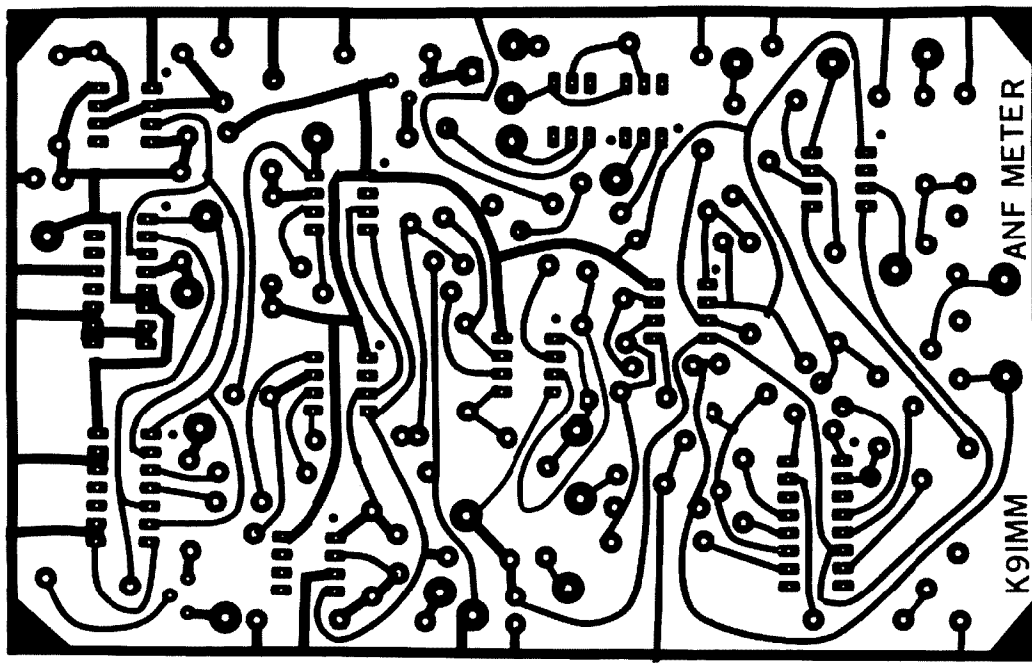
I-f strip.

operation

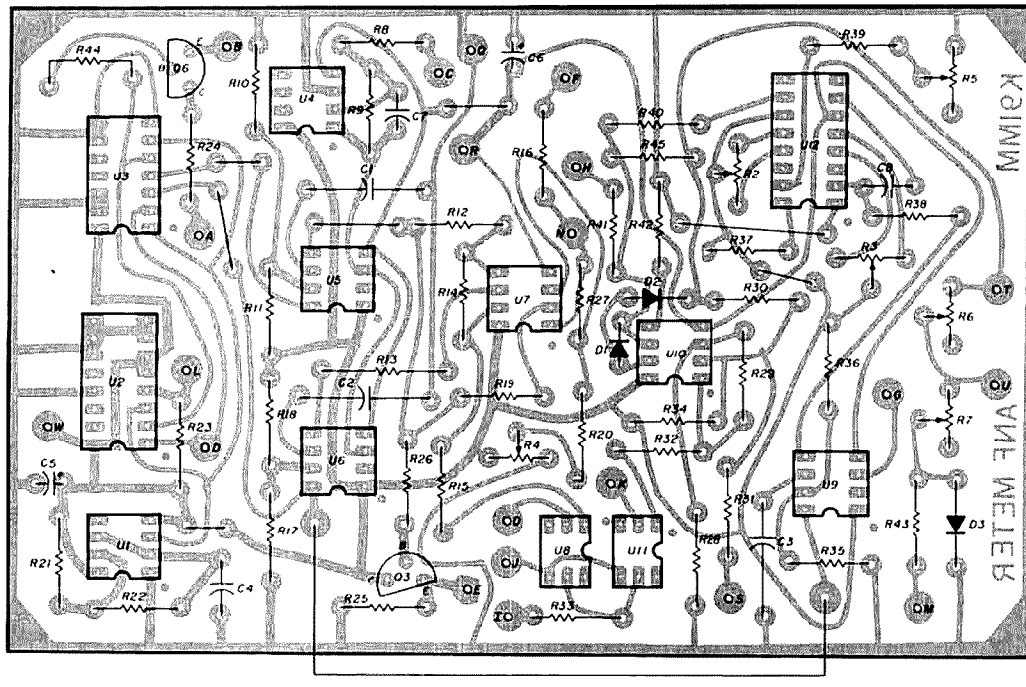
The reader is referred to the article by W6NBI on automatic noise-figure measurements for background on proper use of ANF meters.[3] A few comments pertaining to this particular meter are in order. Fifty-ohm output impedance of the receiver under test is required for accurate operation of the input pad in the meter. Amplifiers and converters seldom have 50-ohm output impedance, so a 3-dB or greater pad should be inserted between the receiver under test and the meter input. This pad won't cure the mismatch, but it will swamp out its effects on the measurement.

The receiver under test must be stable, since the meter is unable to tell the difference between noise and oscillation. In the same vein, if you are in a high rf-level area, the receiver should be well shielded. I live within three miles of four TV stations, four commercial fm stations, and a multitude of commercial and Amateur repeaters and paging services; consequently I find it difficult to get proper measurements on unshielded converters or preamps.

An i-f output jack is mounted on the front panel for connection to a scope to verify proper operation of the comparison circuitry. Fig. 6 shows what the scope picture should look like. The important thing is that the N_1 and N_2 sample periods should be at the same level. The large negative pulse at the beginning of the source *off* period is caused by the source not turning off immediately. This is because of the finite discharge time of the bypass capacitors in the filament circuit of the source. A 5-way binding post mounted on the front panel is used as a handy source



PC-board layout, foil side.



PC-board layout, component sido.

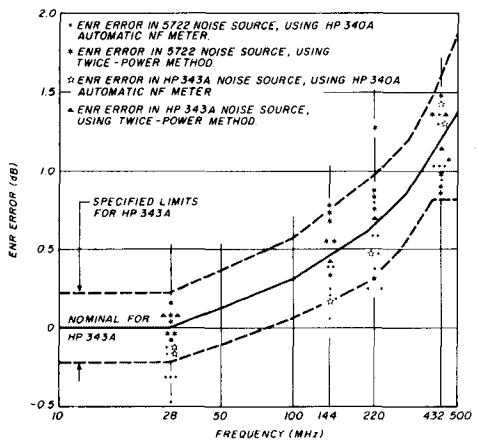


fig. 9. ENR error as a function of frequency for the HP-343A or 5722 source (from reference 1).

of +15 volts to supply converters and amplifiers. When working with preamps with a sub-3-dB noise-figure, be aware that the input impedance for best noise figure is seldom 50 ohms. This presents a mismatch to the source and indicates an erroneous noise figure, which is usually too high. A 3-dB pad between the source and the receiver input will swamp out most of the error. The 3-dB-pad effect can be nulled out by the compensation pot, so the meter will read noise figure directly. I use the technique in fig. 7 to measure converters or preamps. The first 3-dB pad terminates the source, and the 20-dB-gain amplifier after the preamp under test reduces the effect of mixer loss on noise figure to a negligible level. The mixer is a broadband, double-balanced mixer (ANZAC MD-108) packaged in a small box with BNC connectors for the ports. The 3-dB pad after the mixer terminates the switched pad in the meter. The signal generator supplies local-oscillator power at $f \pm 28$ MHz. If the amplifier has a reasonable noise figure ($\leq$4 dB), and the preamp has a reasonable gain ($\leq$15 dB), then the compensation for a 2-meter preamplifier would be figured as follows: At 144 MHz, ENR error is +0.45 dB. A 3 dB pad is used so that compensation is $0.45\,dB - 3\,dB = -2.55\,dB$.

Set the compensation pot to −255 and read the system noise figure directly from the meter.

The method for determining preamplifier noise figure from system noise is:

$$NF_1 = 10 \log \left[F_S - \left(\frac{F_2 - 1}{G_1} \right) - \left(\frac{F_3 - 1}{G_1 G_2} \right) - \ldots \right]$$

NF_1 = *preamp noise figure (dB)*

F_S = *system noise factor*

G_1 = *preamp numerical gain*

G_2 = *second stage numerical gain*

F_2 = *second stage noise factor*

F_3 = *third stage noise factor*

Note that this formula uses noise factors and numerical gains, *not* noise figures and decibel gains.

If the source terminating resistor temperature is other than 290 K (62 F), a correction must be made for this error. 290 K (62 F) is below room temperature, and the resistor is very close to a hot tube, so this correction is usually necessary. Unfortunately this is a non-constant error, so the compensation pot can't be used. The best technique is to factor the other errors into the compensation pot correction and then use that figure to work up the temperature correction from fig. 8. The ENR correction for frequency for the HP 343A source and the W6NBI 5722-type source is given in fig. 9. This error should be nulled out as a + compensation with the compensation pot. Be aware that the source accuracy is the limiting factor for the measurement accuracy. I suggested that the hot-cold resistor noise figure measurement system be used to verify the excess-noise ratio output of the source at various frequencies.[4] If this is done, this meter should be as accurate as the commercial models.

Noise figures, like antenna gains, *are numbers* that are often claimed but seldom measured. My involvement in this project has been well worth the effort, especially when I see the long faces (mine included) on the owners of "hot" preamps when the meter reads otherwise.

I'd like to acknowledge the assistance of W9XM and WA9ACI in reviewing this paper and for many spirited discussions on the philosophy of noise-figure measurement.

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2. "Noise Figure Primer," Hewlett Packard Application Note 57, January, 1965.
3. Robert S. Stein, W6NBI, "Automatic Noise Figure Measurements — Fact and Fancy," *ham radio*, August, 1978, page 40.
4. Benjamin L. Lowe, K4VOW/WA5UUM, "Hot and Cold Resistors as UHF Noise Sources," *QST*, September, 1976, page 32.

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2. Krauss, Geoffrey H., WA2GEP, "VHF Preamplifiers," *ham radio*, December 1979, pg. 50.
3. Intersil 8048/8049 Application Note, Intersil, Inc., Cupertino, California.
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ham radio

Amateur Radio equipment survey

Detailed reports from owners of several models of popular Amateur Radio gear were featured in various issues of *Ham Radio Horizons*. These reports were received with much favor by readers who were contemplating the purchase of equipment, either new or used.

This month we continue our owners' equipment survey by selecting for review three radios that have enjoyed much popularity in the Amateur community. The radios have been in use long enough so that a fairly broad sample of opinion and experience can now be collected. They are the Icom 701, Drake TR-7, and Kenwood TS-520 series — all high-frequency transceivers.

The items in the owners' report form have been chosen to extract the most information of use to the prospective buyer in making his choice. The results of the survey will show what owners really think about their equipment — what was best liked, what was disliked, what types of problems were encountered and how they were resolved, and in general what owners felt about performance, maintainability, and reliability.

Reading the results of the survey will surely help you decide how to spend your money for that new rig. You can profit from the experience of Amateurs who have learned by doing — putting the equipment to work under actual operating conditions. Such information can be much more meaningful than a laboratory report made from tests under controlled conditions.

The report sheets can be even more useful if comments are added, in addition to answers being checked off where called for. Feel free to let us know your opinions. The more information we can gather, the better we'll be able to serve prospective buyers.

Next month we'll be publishing the first part of our two-part rundown on Collins gear, in which we'll present the data we've collected from users' comments on the KWM-2 and KWM-2A transceivers. In the April issue, we'll appraise the 32S-series transmitters and the 75S-series receivers. As in the past, the readers of *ham radio* have made some perceptive and revealing comments on the equipment they own and use. If Collins equipment interests you, be on the lookout for these two articles.

80-meter receiver for the experimenter

Basic building blocks for those who like to build their own gear

This simple receiver covers the 80-meter band. Other bands can be received by adding converters. This article has been submitted with the idea of giving other experimenters some ideas about receiver construction. A simple low-frequency i-f filter is also included. It provides a bandwidth of about 1200 Hz — great for CW if the band isn't too crowded. The nice thing about the filter is that it's inexpensive: two crystals at $2.00 each plus a few other parts (also inexpensive).

description

My receiver was built on a 5 × 9 inch (12.7 × 23 cm) chassis with a panel measuring 9 × 5 inches (23 × 12.7 cm). I found room for a power supply and small speaker. The dial was Japanese. With a switch on the back of the chassis I can change to battery operation instead of the ac supply, thus making a nice portable receiver that will fit into a travel bag.

antenna input circuit

No rf stage was used in this receiver design because I anticipated that converters would be used for higher-frequency bands. An rf stage isn't needed on 80 meters — this saves some space. The antenna is fed directly into an attenuator, which I found necessary to prevent receiver overload. The attenuator was made from a dual 10k-section pot (see **fig. 1**).

The antenna coils are double tuned with separate 100-pF capacitors for simplicity rather than a split stator capacitor. This eliminates the tracking problem and hard-to-find parts.

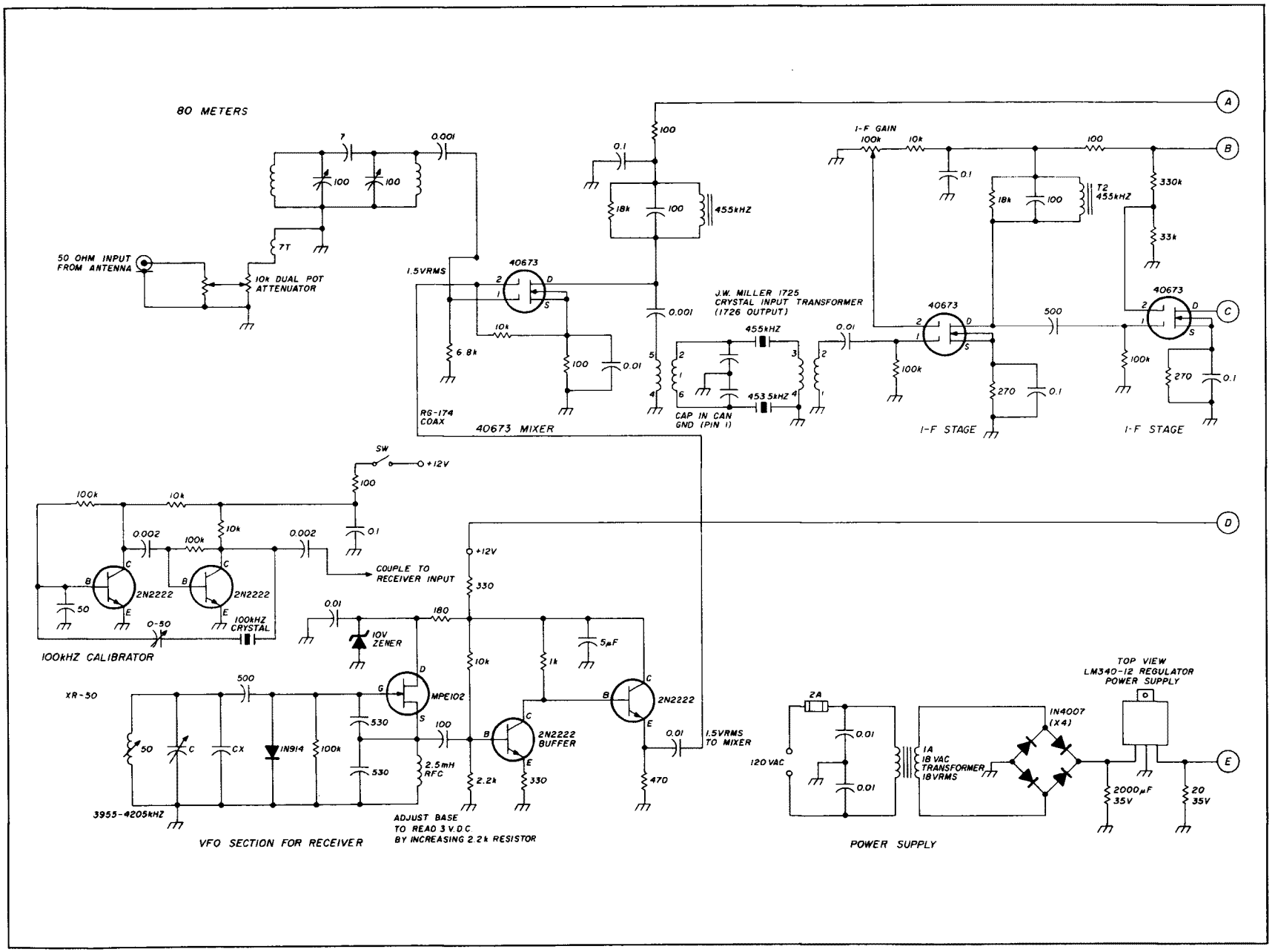
The antenna coils are wound on red Amidon cores. I used T-80-2, 1 inch (25.4 mm) in diameter, because they were available. The 68-2 will also be correct — anything to resonate at 80 meters. It takes about forty-five turns of no. 26 (0.51-mm) wire using a 100-pF variable for tuning. I used a 50-pF and padded it for resonance at mid-capacitor position. Resonance can be checked using a grid-dip oscillator with a loop around its coil and one around the toroid.

mixer

A 40673 dual-gate MOSFET was used for the mixer. The resistor in gate 1 isn't critical and can be anything from 6.8k to 100k; however, the lower values are better, as overloading is possible with higher values.

I lucked out for a coil in the drain circuit: a small, potted, ceramic toroid about 1 inch (25.4 mm) square. I found it in a bag of coils sold by Radio Shack. It's not listed in their catalog, so it is worth looking for in the store. Otherwise, a J.W. Miller variable slug coil 4515, a 350 μH to 475 μH inductance

By Ed Marriner, W6XM, 528 Colima Street, La Jolla, California 92037


80 METERS
7
0.001
100
100
7T
50 OHM INPUT FROM ANTENNA
10k DUAL POT ATTENUATOR
1.5VRMS
40673
2
1
D
S
6.8k
10k
100
0.01
RG-174 COAX
40673 MIXER
0.1
100
18k
100
455kHZ
0.001
5
4
J.W. MILLER 1725 CRYSTAL INPUT TRANSFORMER (1726 OUTPUT)
455kHZ
453.5kHZ
CAP IN CAN GND (PIN 1)
I-F GAIN
100k
10k
100
0.1
18k
100
T2 455kHZ
330k
33k
40673
0.01
500
100k
270
0.1
I-F STAGE
40673
100k
270
0.1
I-F STAGE
A
B
C
D
E
SW
+12V
100
100k
10k
0.1
0.002
10k
0.002
100k
2N2222
2N2222
50
100kHZ CRYSTAL
0-50
100kHZ CALIBRATOR
COUPLE TO RECEIVER INPUT
+12V
330
0.01
180
10V ZENER
10k
1k
5μF
2N2222
XR-50
500
MPE102
530
100
2N2222 BUFFER
0.01
1.5VRMS TO MIXER
50
C
CX
IN914
100k
530
2.5mH RFC
2.2k
330
470
3955-4205kHZ
ADJUST BASE TO READ 3 V.D.C. BY INCREASING 2.2k RESISTOR
VFO SECTION FOR RECEIVER
2A
120 VAC
0.01
0.01
1A 18 VAC TRANSFORMER 18VRMS
IN4007 (X4)
TOP VIEW LM340-12 REGULATOR POWER SUPPLY
2000μF 35V
20 35V
POWER SUPPLY

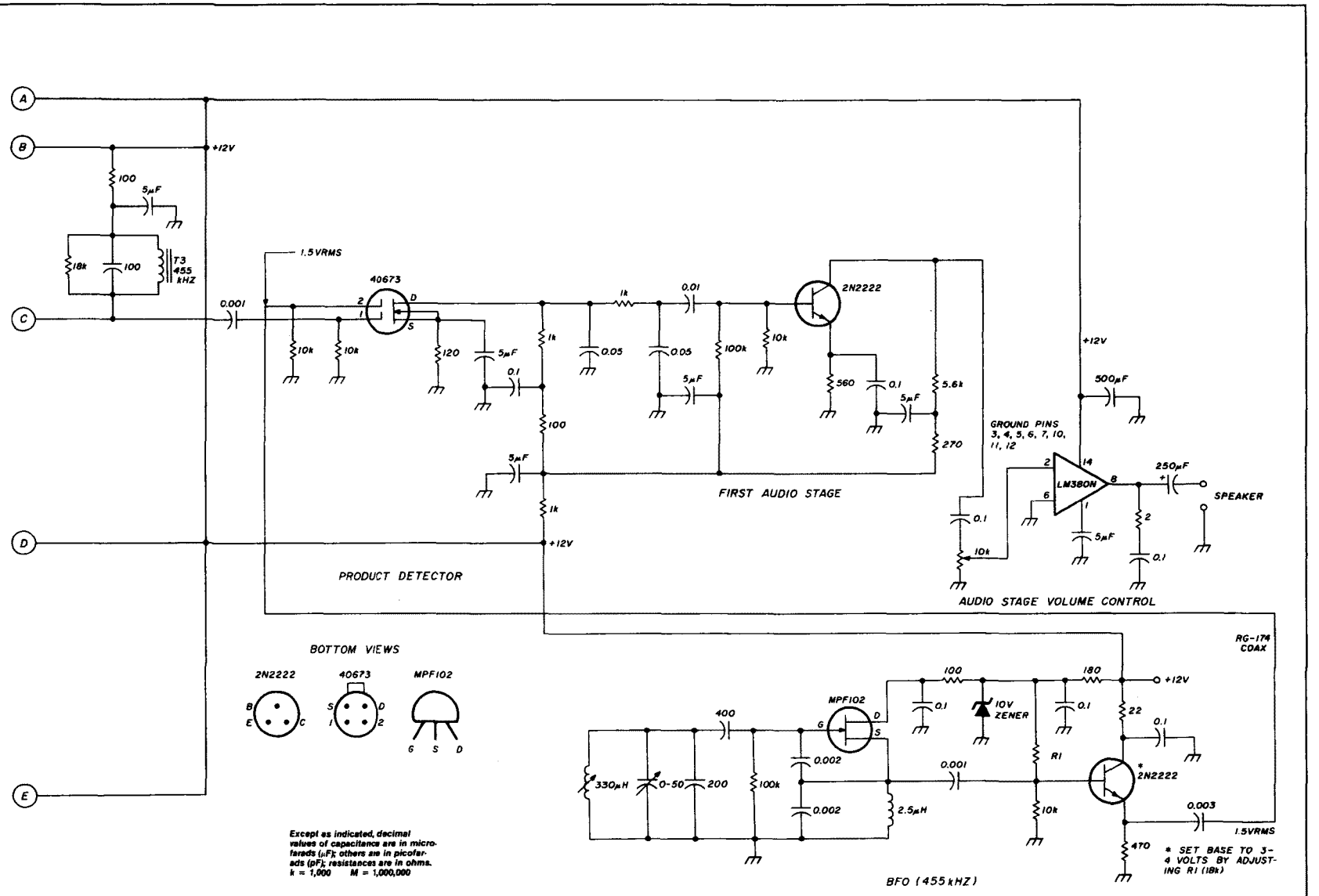


fig. 1. Schematic of the 80-meter receiver. Easy to build and easy to get working, it's a good project for those who like to experiment.

with a 220-pF capacitor should work. Another solution is to use half of an old 455 kHz i-f transformer.

crystal filter

The filter was made with two crystals, one of 455 kHz and one of 453.5 kHz. This is great for CW with a bandwidth of about 1200 Hz. However, a little wider spacing could be in order for SSB. The reason for these particular crystals is they are inexpensive: $2.00 each from the source indicated. The J.W. Miller Company offers an input and output transformer (1725 and 1726) to match crystals for the filter. Note that the capacitors in the output of the 1725 transformer are inside the can. You don't need to add them; just ground pin 1.

i-f stage

Two i-f stages were used, although it might be possible to get by with only one as the gain of this receiver is pretty high. I used two stages and reduced the gain with the i-f gain control.

product detector and audio

Rather than using a passive detector with diodes I used a 40673, which has some gain, to drive the first audio stage: a 2N2222. The product detector needs about 1.5 volts RMS injection voltage. I've had pretty good luck with this audio circuit, which delivers about 2 watts into a big speaker. Other lower-powered chips are available, but I used this circuit, which is in most of the commercial sets in use at the moment.

BFO

A crystal-controlled BFO could be used, but I've had difficulty making crystals oscillate at this frequency so I used the variable BFO. It's also very useful for zeroing in SSB signals and changing CW pitch. It's very stable, with no pulling.

VFO

The VFO tunes 3955-4205 kHz to cover the 80-meter band. It will take a little playing around to get it right. It's nice if you can borrow a counter or have a receiver that will cover this range. I used a National XR-50 5/8-inch (15.9 mm) diameter slug-tuned form for the coil. I had some silver wire that was nylon covered. It was no. 24 (0.511-mm) diameter. Using this wire, the VFO was very stable, but locating such wire is difficult. (This wire was found at a flea market; enameled wire is the next best choice.)

The variable capacitors available will determine your bandspread: capacitors of 0-50 or 0-100 pF will cover the range, or you can use a switch and two silver mica padding capacitors, which is what I did to cover the 80-meter band in two steps.

The capacitors I used from gate to ground and the coil coupling capacitor also have an effect on the tuning. The coupling capacitor has an effect on the oscillation and its value sometimes must be reduced. However, with the values shown, the VFO worked well and produced 1.5 volts rms — enough for mixer injection. While many circuits don't show buffers, I've found that signals don't pull the oscillator if a buffer is used. Thus, the set is more stable.

construction

Because of the difficulty in obtaining parts these days, it's impossible to specify an exact component (see table 1). I search the surplus ads, flea markets, and surplus stores. One of the best sources is the flea markets that radio clubs sponsor. There I've found all my parts.

This set was made from copper board and black drafting tape and dots, then etching. The board was mounted onto the chassis using spacers. I cut my panels with a hacksaw, with the aluminum held between two pieces of angle iron secured in a vice. After drilling, I dipped the panel in lye water. Or I let the panel set in *Lime Away*, a grocery store product, overnight.

Sometimes I spray the panel with black crackle paint and bake it in the oven at 175F for 15 minutes. The finished products look good. The boards can be dipped into a tinning solution to make them commercial-looking.

Holes for parts are drilled with a number 60 drill. There are a lot of little things you can do to make your homebrew projects look nice if you so desire. Many hams just want them to work, but I like to have them look nice, too.

table 1. Suggested sources for parts.

J.W. Miller Co.
19070 Reyes Avenue
Compton, California 90221

Low Frequency Crystals ($2.00 each):
John L. Winton
8062 San Mateo Cr.
Buena Park, California 90621

Radio Shack Stores

Integrated Circuits Unlimited
7889 Clairemont Mesa Boulevard
San Diego, California 92111

Semiconductor Supermart
P. O. Box 3047
Scottsdale, Arizona 85257

ham radio

solid-state power for 1296 MHz

Here's a Class C amplifier that delivers 2 watts of output power

In the past few years quite a few construction articles describing preamplifiers, converters, filters, and test equipment for the 1296-MHz band have been published. However, there has been a conspicuous lack of articles about transmitters for this band. This is a serious omission, because, for reasonable communications range, a transmitter power of at least a watt or two is needed — far more than the milliwatts produced by most converters.

background

Most of the 1296-MHz transmitters[1,2,3] described in the last decade have used surplus microwave tubes as the active components in the final stages. These planar triode tubes, commonly known as "lighthouse" tubes because of their distinctive shape, have been available on the surplus market for many years. And, although amplifiers built around this type of tube are capable of delivering tens or even hundreds of watts output, they suffer from at least two drawbacks that have limited their popularity.

First, the tubes are normally operated in a cavity or coaxial type of structure. Fabrication of these types of matching networks is not particularly difficult, but some machine shop work is generally required. Second, these tubes, usually of the type 2C39 family, are becoming somewhat scarce on the surplus market, as the original users of the tubes have largely switched to diode and transistor devices for medium-power amplification at the lower microwave frequencies.

At the present time, bipolar transistors are commercially available that are capable of at least 40 watts of continuous output at one GHz and 20 watts at 2 GHz, approximately the same power level to be expected from a single 2C39 tube.

Few Amateurs have built transistor power amplifiers for the 25-cm ham band, however. This is mainly because microwave transistors have a reputation for being expensive, tricky, and easily destroyed[4]. But with recent improvements in technology, rf transistors have become not only better but also more rugged, while the cost per unit has dropped because of the tremendous increase in the volume of production. As a result, transistor amplifiers capable of producing several watts output power are now easily within the technical and financial reach of Amateurs.

This article describes a two-stage amplifier chain that will deliver over 2 watts output. The total gain of the two units together is at least 30 dB, which means that a few milliwatts of drive power from a low-level converter or exciter will produce full output. The amplifiers are sufficiently broadband to cover the entire 1250-1300 MHz range, so that once tuned up they need not be retuned for operating frequency changes.

Construction of these amplifiers is straightforward and only hand-tool work is required. They are built using a mixture of microstrip line and lumped component techniques on copper-clad boards. Each stage is built as a module with 50-ohm input and output to simplify testing and to increase flexibility.

The first stage produces at least 100 milliwatts of linear output power. The gain at this power level is approximately 17 dB. The next stage provides a minimum of 2 watts output. It is operated Class C and has a gain of 13-14 dB. When the two are cascaded together as shown in fig. 1, a 2-milliwatt drive signal will produce over 2 watts output. Alternatively, the first stage may be used alone as lower-power transmitter to produce up to 150 milliwatts of saturated power.

By Jerry Hinshaw, N6JH, 4558 Margery Drive, Fremont, California 94538

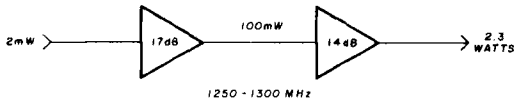


fig. 1. Block diagram of the microwave amplifier chain showing typical powar levels. Total stage gain is at least 30 dB. Broadband design ensures coverage between 1250-1300 MHz, so that no retuning is needed for frequency changes.

100-mW stage

The first stage of the chain is a linear, Class A amplifier. As such, it's designed using the small-signal, grounded-emitter, s-parameter information provided by the manufacturer.

The transistor used in this stage is a Hewlett-Packard 2N6679, also known as the HXTR 2101. There are several reasons for selecting this transistor in preference over another, even though at approximately $22 it isn't the most inexpensive device available. This microwave transistor is designed to produce moderately high linear output power and is therefore fully characterized for this type of operation. Second, it has a higher matched gain than most less-expensive transistors. This means that one less gain stage is needed to amplify a signal up to the 100 mW level required to drive the output stage. This reduction in system complexity more than offsets the higher initial cost of this one stage.

The design of this amplifier follows the approach described in detail by Shuch.[5] Each input and output matching networks consists of a series quarter-wave transmission line transformer that matches the real part of the transistor input or output impedance. Shunt capacitance is used to compensate for the reactive portion of the output impedance. The input impedance of this transistor is by coincidence nearly a pure resistance at this frequency, so that satisfactory matching is achieved without a shunt capacitor at the transistor base. A schematic diagram of this amplifier is shown in fig. 2.

The design is accomplished using s-parameter data for 1275 MHz, data which were obtained by interpolating the 1.0- and 1.5-GHZ data provided by the manufacturer. Although such a design is, strictly speaking, valid for only this one frequency, in practice the s-parameters do not vary rapidly for small changes in frequency, so the usable range is a band several per cent wide centered at 1275 MHz.

The input impedance of this transistor at 1275 MHz is found to be approximately 5.3 ohms. As it is very nearly a pure resistance, it can be matched with only a quarter wavelength transformer whose characteristic impedance is 17 ohms. This 17-ohm transformer is realized on 1/32 inch (0.8 mm) glass-epoxy board by a microstrip line approximately 0.225 inch (5.7 mm) wide and 1.14 inches (29.0 mm) long.

At the transistor collector the impedance is approximately 50.6 ohms in series with 110.9 ohms of capacitive reactance. The real part of this impedance presents a good match to the 50-ohm load as it is, without further matching. The reactive part of the impedance is tuned with a capacitor located a quarter wavelength from the transistor. This capacitor must have a reactance of 22.5 ohms, corresponding to 5.7 picofarads at 1275 MHz. The quarter wavelength line itself is 0.056 inch (1.4 mm) wide and 1.15 inches (29.2 mm) long on this 1/32-inch (0.8-mm) printed circuit board material.

Dc power is provided by the constant-current bias network shown in the schematic. In an earlier version of this amplifier a simpler, passive bias scheme was used, but it proved to be a false economy because bias instabilities destroyed the HXTR 2101 transistor. The present circuit automatically compensates for the current gain variations from one transistor to another and for variations that result from temperature changes. Thus it provides for stable, Class A operation. Collector current is held at 25 milliamperes while the collector-to-emitter voltage (Vce) of the rf transistor is stabilized at approximately 15 volts.

construction

The amplifier is built on a piece of double-clad Fiberglass epoxy PC board material 1/32 inch (0.8 mm) thick. One side of the board is left fully clad with copper to serve as a ground plane for the microstrip

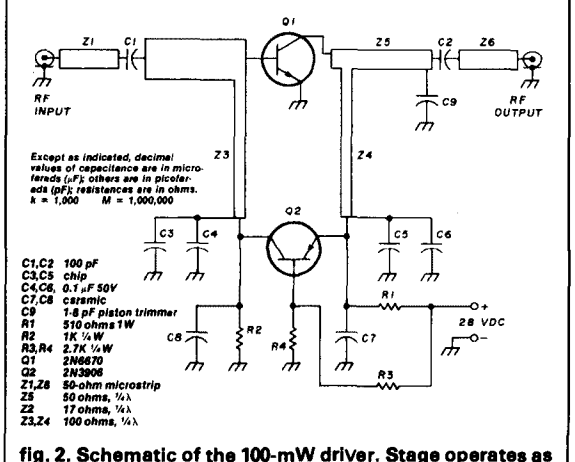


fig. 2. Schematic of the 100-mW driver. Stage operates as a Class A amplifier, producing linear output using the H-P 2N6679 device (also known as the HXTR-2101).

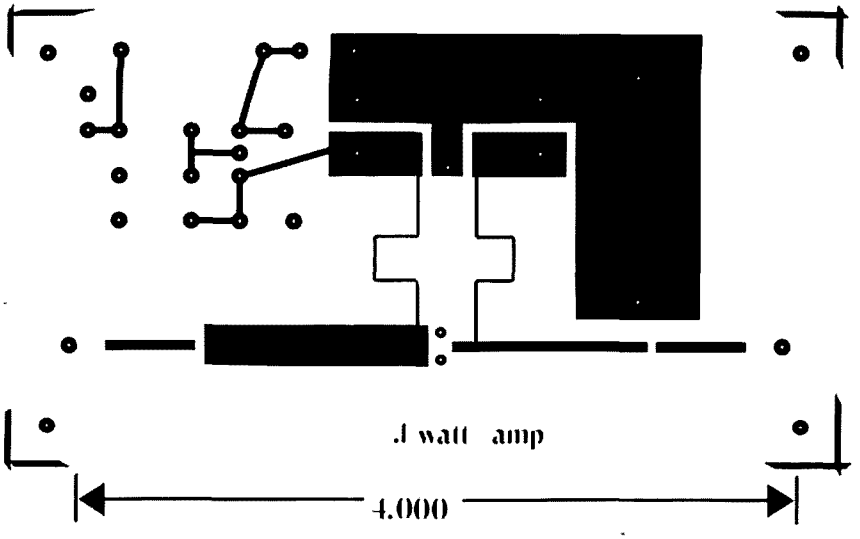


fig. 3. Full-size illustration of the PC board for the 100-mW driver stage.

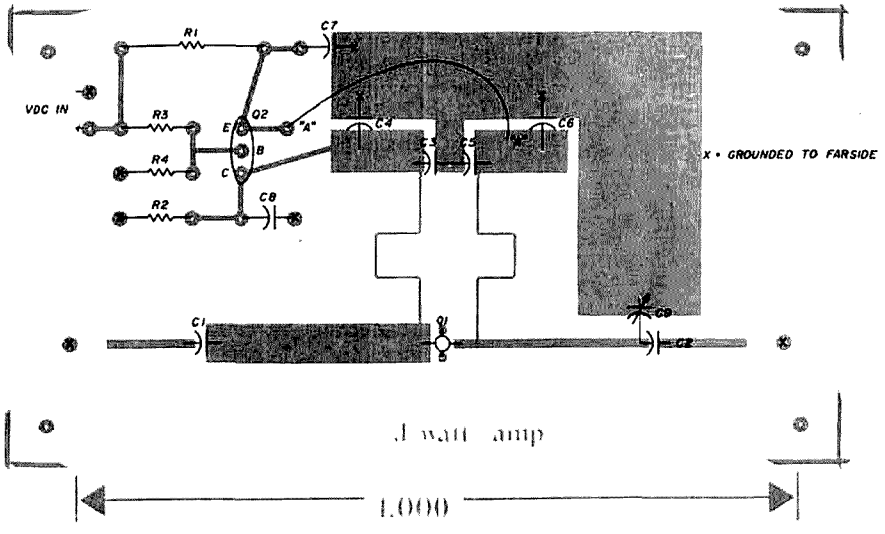


fig. 4. Component placement for the 100-mW stage.

lines. The other side is etched to form the matching and bias circuit mounting areas. A full-scale illustration of this side of the board is shown in fig. 3.

Feedthrough eyelets are mounted in the board at the positions marked on fig. 4 with an X. These eyelets are used to help ensure that the two emitter leads of the transistor are connected to ground by low impedance paths and at the ground ends of the tuning and bypass capacitors. Solder the eyelets to the copper ground plane on the bottom of the board.

Where component leads will protrude through the board, the ground plane must be cleared away to

prevent shorts. This can be done with a small drill. Clear away enough copper from around the hole to ensure that the component doesn't touch anything but Fiberglass.

Once the fabrication of the board is done, the components are installed as shown in **fig. 4**. The 2N6679 and the chip capacitors are mounted on the top of the board, while the bias circuit components are installed on the ground-plane side. Be careful when soldering the transistor that solder does not flow underneath the package and short out any of the leads. The transistor package is very small, and the leads come quite close together on the bottom side, so that it's easy for even a tiny amount of solder to wick along one lead and short to another. Also, note that the variable capacitor in the output circuit must be mounted right at the output end of the quarter-wave line for maximum performance.

The two emitter leads on the 2N6679 are bent at right angles to the transistor package so that they will fit through the two eyelets to the ground plane side of the board to be soldered. It's important that the emitter leads be connected to the ground plane by low impedance paths if the amplifier is to perform properly. To get a low impedance path, the transistor package should be mounted flush with the PC board so that the emitter leads are as close as possible to the feedthrough eyelets.

The input and output connections are made with small-diameter 50-ohm coaxial cable such as RG-179 or similar. The coax-cable shield is twisted into a pigtail and run through the hole in the PC board near the end of the microstrip matching lines. Then the shield is soldered to the ground plane of the circuit board. On the etched side of the board, the center conductor is soldered to the end of the microstrip transformer. The distance between the end of the coaxial shield and the center conductor soldered connection should be as short as reasonably possible. A length of 0.2 inch (5.1 mm) works well. A jumper wire is run between the two points marked with an **A** in **fig. 4**.

The completed board is installed in a small sheet-metal chassis box by means of four standoffs. The two coaxial cables are run to connectors mounted in the box wall and a feedthrough capacitor is used to bring in dc power for the amplifier.

tuning

Connect the amplifier to a 28-volt power supply and check to see that the supply current is approximately 30 milliamperes. As a further check of the bias, measure the voltage at the 2N6679 collector. It should be about 15 volts above ground.

If you're hesitant about trying out an untested bias circuit with your somewhat expensive rf transistor, you can first test the circuit by soldering a small-signal NPN transistor in place of the 2N6679. The amplifier won't work at 1250 MHz, of course, but the small-signal transistor will duplicate the dc operation of the rf transistor. If the bias circuit properly regulates the collector voltage and current of this "fuse," then it is safe to go ahead and install the 2N6679.

Tuning the amplifier requires a signal source of about 1 milliwatt and a power meter or signal detector of some sort. Apply dc power and the rf drive signal, then tune the output matching capacitor until maximum output is seen. If the amplifier is tuned up at 1275 MHz, it will cover the range 1250-1300 MHz with less than a dB of gain "droop" at the band edges. Once the output capacitor is peaked, no other adjustments are necessary.

2-watt stage

The final stage of this chain is a Class C common-base amplifier capable of 2.5 watts output power. The transistor used in this stage is the Motorola MRF2001, the lowest-power member of a family of 2-GHz, common-base power transistors. The 2000 series transistors have been available from several manufacturers for a number of years and have come to be an unofficial standard type of microwave transistor. They have been used in many military and industrial designs, but their high cost has kept them out of the range of most Amateur experimentation. However, in late 1978, Motorola announced a low-cost version of this 2000 series designed to penetrate the commercial marketplace.

These transistors are rated for 2-GHz operation, and this means that their performance in the 1250-1300 MHz range can be fairly impressive. It's generally difficult to achieve high gain and high power output simultaneously, but when the device is operated well below its design frequency these two goals can be more easily met. Thus, the MRF2001, rated at 1 watt minimum output with 9 dB gain at 2 GHz, when operated at 1.3 GHz, easily produces 2 watts with an associated gain of 13-14 dB. The cost of these transistors is about $19 each.

design

Since this stage is to be operated as a large-signal, Class C amplifier, the s-parameter design approach used to design linear Class A amplifiers is not appropriate. Instead, matching networks must be designed to present to the transistor the impedances that produce the best input match while simultaneously giving the highest output power.

This approach is different in several ways from that used for small-signal linear amplifiers. In the case of a low-level amplifier, the matching networks are

chosen to maximize gain, and perhaps to minimize the input and output VSWR. By contrast, in a large-signal amplifier, only the input circuit is designed to provide a low VSWR to maximize the driver power transferred into the amplifier. This part of the design is not wholly unlike that of the small-signal amplifier.

At the output of the Class-C stage, however, the intent is to provide that matching network which maximizes the output power. This requirement usually means that output VSWR and overall power gain are compromised somewhat in the interest of increasing output power and efficiency. A detailed discussion of this design approach and of the tradeoffs involved is provided by Pitzalis.[6]

To permit such a design the manufacturer publishes typical impedance data for their rf power transistors. The input impedance they specify gives a good match and hence a good power transfer into the transistor. The output impedance they list is that into which the transistor delivers maximum power at a given drive level.

As with the 100-milliwatt stage, the fractional bandwidth required for the amplifier to cover this ham band is small enough so that the design can be at a single frequency. This approach is much simpler than would be a broadband optimization.

The data sheet for the MRF2001 lists the eqivalent series input impedance at 1250 MHz as

$$Z_{in} = 7.6 + j10.3 \text{ ohms}$$

The best input match will be obtained with a network that presents the complex conjugate of this impedance to the transistor. Thus, we want to design a network that will transform the real 50-ohm input feedline impedance to

$$Z_{in}^{*} = 7.6 - j10.3 \text{ ohms}$$

where the asterisk indicates the complex conjugate.

This series input impedance is equivalent to the parallel impedance[7]

$$Z_{in}^{*} = 21.6 \,||\, -j15.9 \text{ ohms}$$

a resistance of 21.6 ohms in parallel with a capacitive reactance of 15.9 ohms.

At 1250 MHz, a capacitor with this reactance has the value of

$$C = \frac{1}{2\pi f X_c} = 8.0 \text{ pF}$$

If this capacitor is shunted to ground very close to the transistor emitter, the result will be a driving impedance at the emitter of 21.6 ohms, a pure resistance without a reactive component.

To transform this pure resistance to the 50-ohm input impedance, we can use a quarter-wave microstrip transformer whose characteristic impedance is the mean of the two end point resistances, or

$$Z_{input\ line} = \sqrt{(50)(21.6)} = 33 \text{ ohms}$$

This input circuit is shown in the schematic, **fig. 5.**

The required output series impedance is given by the data sheet as

$$Z_{out}^{*} = 9.6 + j23.1 \text{ ohms}$$

The real part of this series equivalent impedance can be matched with a quarter-wave transformer whose characteristic impedance, as before, is given by

$$Z_{output\ line} = \sqrt{(9.6)(50)} = 22 \text{ ohms}$$

The imaginary term can be dealt with by either a series inductive reactance at the transistor collector or by a shunt capacitive reactance at the transformer output. Since it is easier to obtain good, high-Q, variable capacitors than inductors at high frequency, it's better to choose the latter. The reactance required is equal to

$$X_c = \frac{Z_0^2}{X_s} = \frac{(22)^2}{23.1} = 20.8 \text{ ohms}$$

This corresponds to a capacitor of

$$C = 6.1 \text{ pF}$$

A 1-8 pF trimmer capacitor will provide some adjustment range. The completed output circuit is shown in **fig. 5.**

The matching circuits are built on 1/32-inch (0.8-mm) Fiberglass epoxy board material of the type known as G-10. The 33-ohm input line is 0.110 inch (2.8 mm) wide and 1.14 inches (29.0 mm) long. Since the transistor emitter tab is wider than this matching line, and since a shunt capacitor from the emitter to ground is needed, a portion of the required capacitance is distributed in a short open-ended stub. This stub provides about 2.7 pF of the required 8 pF and it is wide enough so that the emitter lead can be soldered over its entire width.

The 22-ohm output transformer is realized with a line 0.190 inch (4.8 mm) wide and 1.11 inches (28.2 mm) long. The output must have a dc blocking capacitor; this should be a microwave chip-type capacitor. A chip capacitor with a 50-mil (1.3-mm) package width will fit the 0.056-inch (1.4-mm) 50-ohm output line with minimum discontinuities. The variable tuning capacitor must be mounted right at the end of the 22-ohm transformer.

Bias voltages are applied to the transistor through two high-impedance quarter-wave lines bypassed to ground at the end away from the matching networks. Since the input is grounded, no dc blocking capacitor is required. At the output, the supply end of the bias line is bypassed to ground with a chip ca-

pacitor in parallel with a higher capacitance ceramic capacitor. The chip capacitor provides effective decoupling at microwave frequencies, while the larger capacitor maintains a low-impedance path to ground down to low frequency.

construction

The construction of this 2-watt stage is complicated somewhat by the fact that both thermal and rf factors must be considered. Good rf circuit techniques are needed so that the potential performance of the amplifier can be achieved, while at the same time the transistor must have a good path for heat transfer, or the heat generated might destroy the

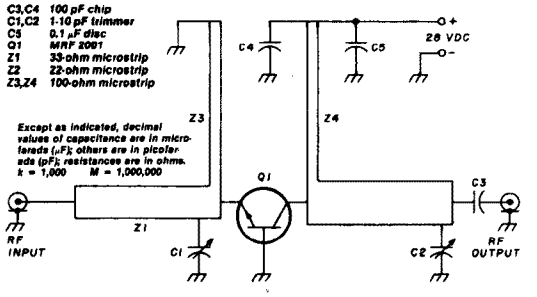


fig. 5. Schematic of the 2-watt amplifier. Simple stripline construction makes for easy assembly. Separate input and output stages are shown, which require two boards.

transistor or shorten its life. For this reason, the transistor package is designed so it can be mounted to a heat sink. If this is properly done, the transistor junction temperature can be kept low enough so that no damage or degradation will occur.

thermal considerations

Heat is a major enemy of power transistors. The temperature of the transistor die or chip inside the package is the critical factor. For a silicon transistor, the maximum allowable junction temperature is usually specified as 392 F (200 C). However, it is very desirable to operate it at a lower temperature than this, since, as a rule of thumb, the transistor lifetime doubles for every 18 F temperature reduction.[8] If the junction temperature is kept below 302 F (150 C), the average time to failure for a gold-metalized transistor, such as the MRF2001, is measured in decades. Since in Amateur applications a transmitter is used only intermittently, a transistor transmitter operated below this temperature should easily outlive its creator.

The data sheet for the MRF2001 states that the thermal resistance, measured from the transistor junction to the mounting flange of the package, is 45 F per watt of dissipation. If the amplifier has an efficiency* of 50 per cent, then, when it is producing 2.5 watts of rf output, it will also be generating 2.5 watts of heat. This waste heat must be carried away from the die. In this instance the transistor junction will be approximately $2.5 \times 45\ F = 112.5\ F$ hotter than the case of the package. If the case itself is held at a temperature of 122 F (50 C), for example, the junction temperature will be a fully acceptable 243.5 F (117.5 C).

To keep the transistor's case below this target temperature of 122 F (50 C), it must be coupled to a cool heat sink with a connection of low thermal resistance. At this power level, if the transistor flange is bolted to a small finned aluminum heat sink the transistor case temperature will remain well below 122 F (50 C) when the heat sink is located in a normal room temperature environment.

assembly

Because of the flange mounting transistor, the matching circuit is mounted on two separate circuit boards, one for the input and one for the output. The board material is 1/32 inch (0.8 mm) thick type G-10 Fiberglass epoxy double clad with copper. Full-scale illustrations of the boards are shown together in fig. 6. The other side of the board is left unetched to serve as a groundplane for the microstrip lines. After etching, the boards are separated along the marked edges. Components are mounted on the boards as indicated in fig. 7.

The transistor is bolted directly to a small aluminum heatsink, which is approximately 1.2 by 4 inches (3 by 10 cm) in size. The heat sink is located on the outside of the chassis box with the transistor mounted on it and projecting through the wall of the box in a hole cut with a 1-inch (2.5-cm) chassis punch.

The boards for the input and output circuits are inside the chassis box and are attached to the heat sink with machine screws that run through the box wall. The distance from the bottom of the transistor case up to the bottom of its stripline leads is 0.12 inch (3.0 mm). This distance is taken up by the box wall, which is about 0.05 inch (1.2 mm) thick, by the circuit board thickness of 0.031 inch (0.8 mm), and by a spacer, which is a small piece of the same type of circuit board. Thus the total height is about 0.11 inch (2.8 mm), so that the circuit board traces fit snugly

*Efficiency of rf power semiconductors has been defined in many ways. Here it is taken to be the ratio of the rf output power to the dc collector input power x 100 per cent.

beneath the transistor leads, ready for soldering. A cross-sectional view of this construction method is shown in **fig. 8.** Device outlines are shown in **fig. 9.**

tuning

One of the more challenging problems facing anyone who tries to tune Amateur microwave equipment is to devise test and tune-up procedures that are effective but don't require the use of elaborate test gear, not available to most hams. For instance, if you have access to a microwave rf sweeping signal generator, a spectrum analyzer and a calibrated power meter, you'll not have any difficulty in tuning this amplifier chain for peak performance. Unfortunately, few of the ham shacks I've visited have been quite so well equipped.

When I first tuned up these two units, I made use of a spectrum analyzer and power meter to tune and

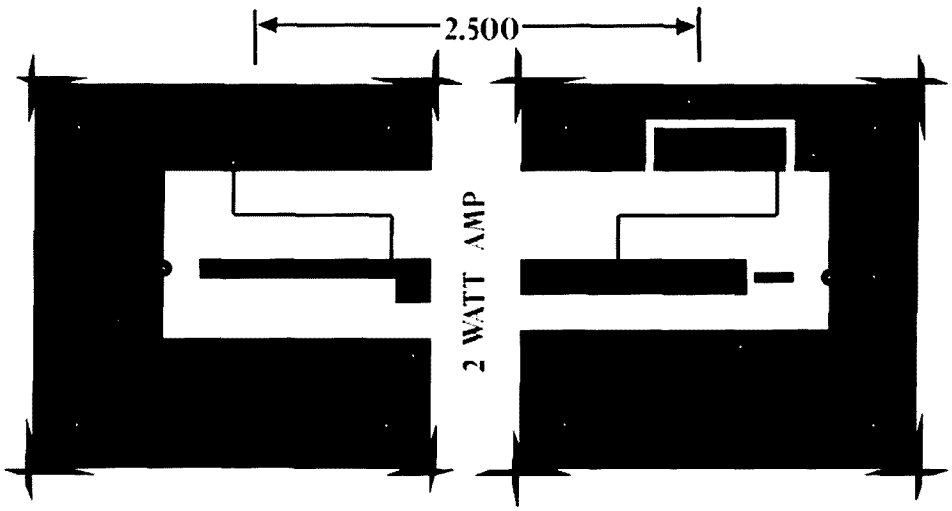


fig. 6. Full-size PC board illustration for the 2-watt amplifier. After etching, the two boards are separated along the marked edges as shown.

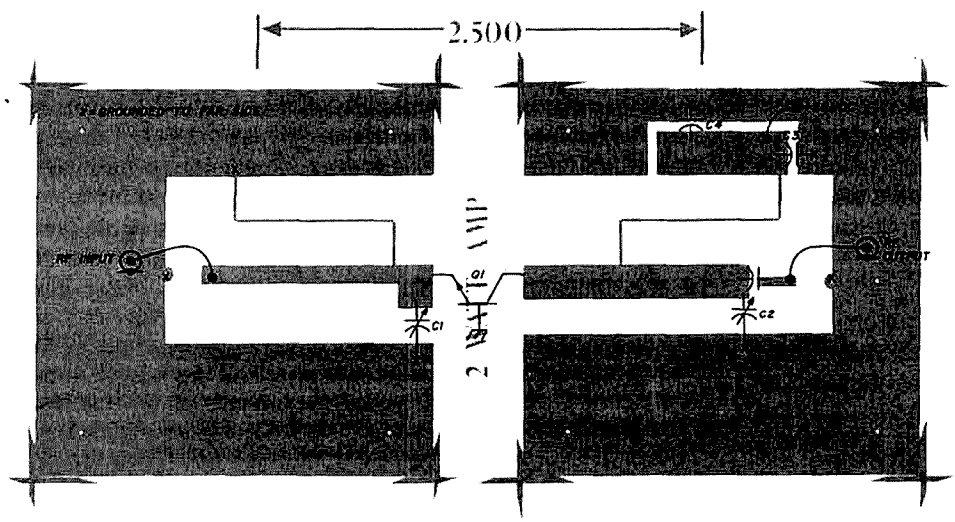


fig. 7. Component placement for the 2-watt amplifier. See text for correct assembly.

to verify that each stage was operating correctly and had clean, spurious-free outputs. Then I detuned them and retuned each at a single frequency using only the power meter, to show maximum signal.

This simplified method worked surprisingly well. Each amplifier had a single peak in output power, a fact that makes tuning with no spectral display easy and not misleading. When the amplifiers are peaked in this way, their bandwidths are wide enough to cover the band and nearly as flat in amplitude response as when they had been tuned with a swept signal source.

To tune up the 2-watt stage using the "no-equipment" approach, you need a signal source that will give a 100-milliwatt output at 1275 MHz, or else at the operating frequency if you prefer to optimize performance there. The first stage driven with a 2-milliwatt signal will serve as a driver, of course. To indicate power, a receiver with a signal-level meter, an rf power meter, an rf millivoltmeter, or a crystal detector may be used.

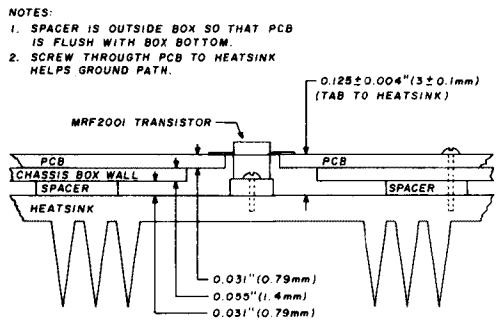


fig. 8. Cutaway view showing transistor mounting detail.

The output from the final stage should not be fed directly into most types of signal indicators, though, because the power level expected would probably damage them. The signal must be reduced to a level that the power meter can safely handle.

One way to do this is to use a directional coupler as shown in **fig. 10**. The amplifier signal is sent through the directional coupler, and a low-level sample of the signal appears at the coupled port.

Alternatively, the output signal can be attenuated with a resistive network as in fig. **11**. A suitable attenuator pad can be built to do this. It is a pi-section attenuator with a loss of 20 dB, so that the output of the Class C final stage is reduced in passing through it to a level of about 20 milliwatts. If this is still too much power for your detector, two attenuators can be placed in series.

The attenuator pad can be built using 1/2-watt, 5 per cent carbon composition resistors by following the schematic shown in **fig. 12**. The 1/2-watt resistors are used because, although 2-watt-rated resistors would be better able to stand the heat generated by the amplifier output, their physical size leads to excessive reactance at high frequency.

I realize that any microwave engineer would cringe

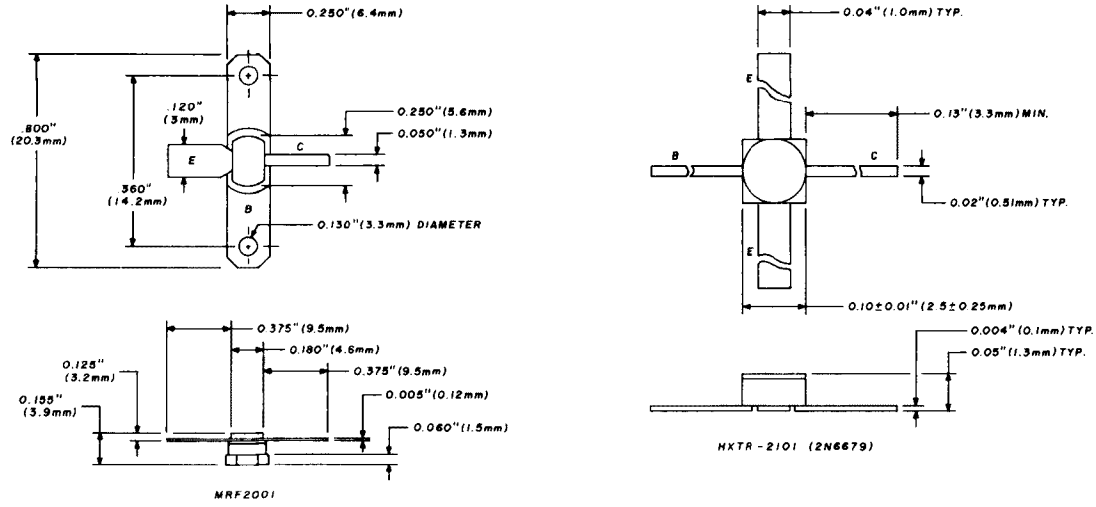


fig. 9. Transistor packages.

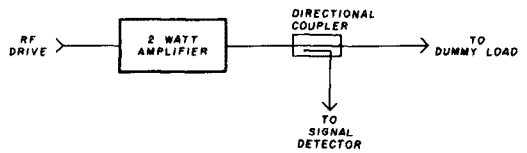


fig. 10. Tuning setup with directional coupler.

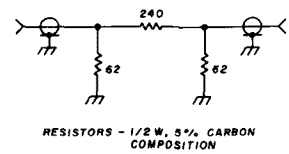


fig. 12. Schematic of the 20-dB pi network attenuator.

at the thought of using such a pi-attenuator at 1300 MHz. However, even though this attenuator is a bit crude, if it's built on a small piece of copper-clad board with the shortest possible lead lengths, it can give an acceptably low VSWR.

This attenuator won't stand 2 watts of rf input for long, so tune rapidly and give the resistors a chance to cool down often. Remember that once heated above a certain point, the resistors will not return to the same resistance they had when new. This will change network attenuation and could lead to errors in tuning.

Once you have the setup together, the hardest part of the task of tuning is done. All that remains is

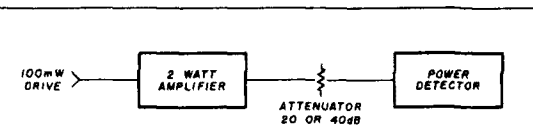


fig. 11. Tuning setup using an attenuator.

to apply the drive signal and peak the two variable capacitors for maximum power output. It's best to go back and forth between the two capacitors a few times; their adjustments do interact a bit.

Fig. 13 shows the final result of this method of tuning. It shows the output of the cascaded system when the input signal is held at a constant 2 milliwatts and swept in frequency from 1250 to 1300 MHz. The output is greater than 2 watts across the band and is nearly 3 watts at the center point.

The final amplifier stage draws about 165 milliamps at 28 volts when producing 2.3 watts output. This indicates that it's operating at approximately 50 per cent efficiency. No attempt was made to tune for better efficiency, although this can often be done.

conclusions

The amplifiers described here are stable, fairly inexpensive, and simple to reproduce. Second stage output power is sufficient to provide solid horizon coverage for voice communication when used with only a moderate gain antenna. The flexibility of the modular construction means the amplifiers can be adapted to a range of uses.

The final stage was biased as a Class C amplifier for use in an fm system. In SSB or ATV service, however, a more linear amplifier is needed. It is likely, as the manufacturer suggests, that the transistor could be operated in Class B, although I have not tried this.

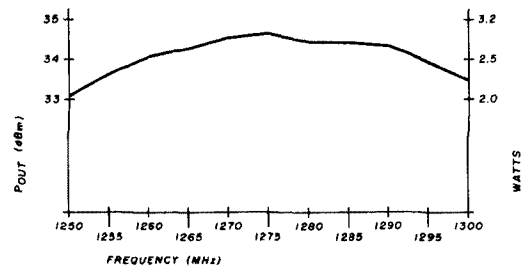


fig. 13. Power output as a function of frequency for the amplifier chain shown in fig. 1. Input is 2 milliwatts.

references

1. Joe M. Cadwallader, "1296 MHz Trensverter," *ham radio*, July, 1977, page 10.
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ham radio

ham radio TECHNIQUES

Bill Orr W6SAI

Diana to EME in 20 years

Sharp-eared newcomers to the Amateur bands may occasionally hear operators talking about EME schedules. A recent issue of *QST* magazine listed the scores earned by stations engaging in an EME contest. How did it all get started?

For years man has dreamed of reaching the moon. Jules Verne wrote about it. In 1930, a well-known inventor and science writer told how it would be possible to use the moon as a reflector to bounce very short radio waves around the earth (**fig. 1**). But nobody had attempted the task; it was an idle dream. No one was even sure that radio waves would penetrate the ionosphere and reach the moon. Perhaps one day this fanciful idea would take root.

While others dreamed, John DeWitt, Jr., W4ERI, decided to act. A Radio Amateur and avid astronomer, John had combined his hobbies while still in high school, and while a young student in Nashville, Tennessee, he had constructed vhf receiving equipment sensitive enough so that he could hear radio noise from the Milky Way — noise which Karl Jansky had discovered a few years earlier.

Finally, in 1940, young DeWitt assembled an 80-watt transmitter, a high-gain antenna, and a sensitive receiver and attempted to send a signal from his transmitter to the moon and back. The experiment was a failure and John set about to determine the cause of his problems. He finally understood that more power, bigger and better antennas and a more sensitive receiver were the keys to success.

The onset of World War II brought all of W4ERI's plans to a stop. Amateur Radio was closed down for the duration. But, as John assumed military service, the idea remained planted in the back of his memory. By then a recognized authority in broadcasting, John rose rapidly in the expanding field of military communications, and by 1944 had risen to the rank of lieutenant colonel and was in charge of the Army's Evans Signal Laboratory at Belmar, New Jersey.

The highly classified work of the laboratory drew to a close in August, 1945, with the abrupt end of the war. DeWitt's important jobs quickly evaporated, but he did not have sufficient discharge points to return to civilian life. He fretted under the boredom and inaction.



fig. 1. A 1930 issue of *Short Wave Craft* magazine featured transmission by moon reflection. A later issue discussed the subject in depth, and noted it was impractical because of the high power needed to overcome path loss. But, the intent was feasible — the article was just ahead of its time.

project Diana

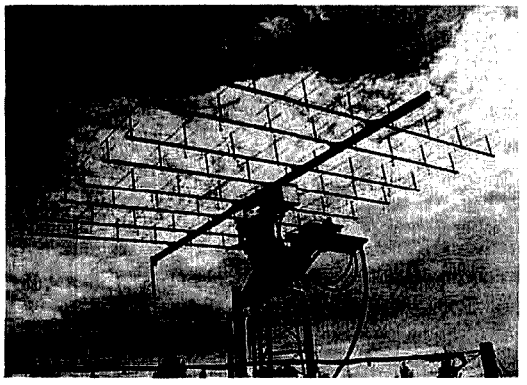
While John bided his time, the Pentagon had a vital question at hand, brought about by the V-2 rocket attacks on London during the war. Was there a way an enemy could direct a rocket attack on the United States using radio-controlled rockets? Could radio and radar signals actually penetrate the ionosphere, or not? Perhaps DeWitt and his remaining laboratory staff could provide the answer.

Once given the go-ahead, John assembled his staff and went to work. Among the group were radio amateurs E.K. Stodola, W3IYF, Frank Elacker, ex-W2DMD, and Harry Kauffman, W2OQU (who would be the first to hear a returned echo from the moon).

The transmitter was an old SCR-271 radar set, much modified, which provided 4-kW output on 111.5 MHz. By combining two radar antennas, DeWitt created an array of sixty-four elements and directors which provided a power gain of nearly 22 dB. His crew built a special superheterodyne receiver of very narrow bandwidth and high sensitivity. All of this, everyday equipment now, was state-of-the-art in 1945.

DeWitt and his crew had to design very special test equipment to make sure their exotic moon-bounce station was performing properly. Calculations showed the project would work and that reflected signals could be detected from the moon — but nobody was *sure* it could be done.

No matter. DeWitt forged ahead, and by January, 1946, he was ready for on-the-air tests. Preliminary tests in December had been inconclusive but he felt that his team was on the verge of success.



The elaborate 432-MHz moonbounce antenna array of ZE5JJ in Rhodesia boasts 128 elements and can track the moon automatically. Peter has since constructed a parabolic reflector using aluminum angle stock and wire screening. It has been very successful.

On the morning of January 10, 1946, DeWitt and his staff fired up the "moonbounce" transmitter. The cumbersome antenna was aimed at the moon, and one-second pulses were sent out every four seconds. Finally, after an agonizing wait, they heard the first echo return on a loudspeaker and saw the returned signal on an oscilloscope connected to the receiver. For the first time, man had touched the moon with an electronic signal and the moon had answered back.

Project Diana was a success and fired the imagination of the public in a manner which may seem surprising in today's more technically sophisticated atmosphere. Soon the U.S. Navy had a microwave moonbounce link from Annapolis to Pearl Harbor. and, very shortly, Amateur moonbounce (EME) circuits would come into being.

amateur moonbounce experiments

It was not until July, 1960, that the first two-way Amateur moon-bounce contact was recorded.[1] It happened on the 1296-MHz Amateur band between W6HB (The Eimac Radio Club) and W1BU (The Rhodedendron Swamp VHF Society). Hank Brown, W6HB, and Sam Harris, W1BU, and their crews worked for weeks getting the equipment ready to go, and finally made contact. Moonbounce communications, using Amateur power levels, was proven possible and it

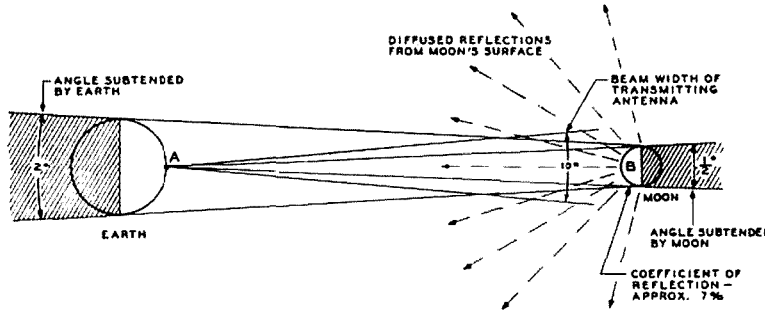


fig. 2. The Earth-Moon-Earth radio circuit. This illustration shows the great obstacles which would seem to make detection of moon-reflected signals highly improbable. The path to the moon and back is about half a million miles and the moon reflects only about 7 per cent of the radio energy striking it. The reflected energy is diffused all over the heavens and only a small portion of the energy which left the radio transmitter is reflected back to earth. Finally, the largest vhf receiving antenna is only a fraction of the earth's pickup area facing the moon. In spite of these staggering difficulties, the earth-moon-earth radio circuit can be made to work with equipment well within the capabilities of many vhf-minded radio Amateurs (drawing courtesy of *Radio Publications, Inc.*).

now remained only to see if other enterprising Amateurs would follow the lead established by these two radio clubs.

Interest grew slowly (possibly because the experiments had been done in a little-used and relatively unknown ham band), and it was not until 1964 that Amateur interest in EME communications was awakened with a jolt when Bill Conkel, W6DNG, ran 2-meter schedules via the moon with Lenna Suomienen, OH1NL, of Finland. Here was real moonbounce with everyday Amateur vhf equipment.

Since those early years, EME interest has grown until today hundreds of Radio Amateurs maintain schedules and experimental contacts via the moon on 144, 220, and 432-MHz.[2] At last, EME has come of age.

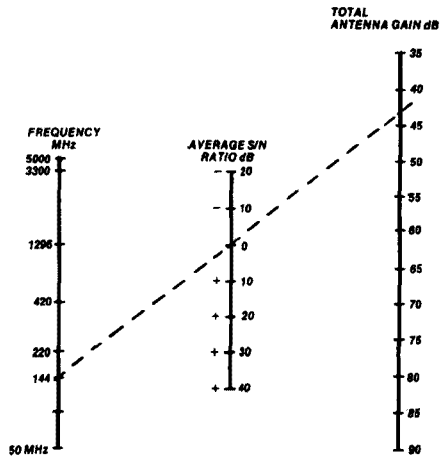


fig. 4. Moonbounce Nomograph provides guideline to successful moonbounce QSO. The graph is based upon 590 watts transmitter power output, zero decibel receiver noise figure, and 100-Hz bandwidth. Lay a straight edge across any two columns and read the desired unknown in the third column. The antenna-gain figures represent a compromise between calculated gain required based upon free space losses and the experience of successful moonbounce experimenters. At 144 MHz, for example, for an average signal-to-noise ratio of zero decibels, a total antenna gain (for both ends of the path) is about 42 decibels. Two 22 decibel gain antennas should do the job.

the EME path

What kind of equipment and antennas does it take to establish a moonbounce station? Who can be worked? Does all the work have to be done at night?

The moon is about 2160 miles in diameter and orbits the earth at a distance that varies from 221,463 to 252,710 miles. An orbit takes about twenty-eight days and is somewhat eccentric, so that the moon travels across a different segment of sky each night of the lunar month. And, although the moon looks quite large when it is full, it subtends an arc of only about 0.5 degree when seen from the earth (fig. 2). Even the highest gain Amateur vhf antenna has a beam width much greater than this, consequently only a small portion of the signal aimed at the moon actually strikes it; the rest passes out into limitless space. Furthermore, an estimated 93 per cent of the signal that does strike the moon is absorbed. Also, as our astronauts verified, the moon surface is exceedingly rough; thus the 7 per cent of the reflected energy is diffused all over space.

Viewed from the moon, the earth subtends an arc of about 2 degrees, and the vhf signal that returns to earth is spread over half the earth's surface, or an area of about 98,470,000 square miles. Clearly, only a small fraction of the transmitted energy ever reaches the eager ears of the moonbounce listener.

EME path loss	distance miles (km)	50 MHz (dB)	144 MHz (dB)	432 MHz (dB)	1296 MHz (dB)	2400 MHz (dB)
Perigee	221,463 (356,334)	177.89	187.08	196.62	206.17	211.43
Apogee	252,710 (406,610)	179.03	188.21	197.76	207.21	212.56

fig. 3. Free-space path loss for earth-moon-earth circuit at perigee (221,463 miles) and apogee (252,710 miles). The nominal 1.14 decibel difference in signal loss between moon perigee and apogee becomes 2.28 decibels for the round trip to the moon and back.

the EME path loss

Because radio signals travelling through space are attenuated at the square of the ratio of the frequency, the path loss to the moon and back is 8.3 times (9 dB) greater on 144 MHz than on 50 MHz. A similar increase in loss occurs between 144 MHz and the 420-MHz band, and between the 420 and the 1250-MHz band (fig. 3). In addition, transmitter efficiency and receiver noise-figure both tend to become worse with increasing frequency. Thus, there are compelling reasons to use as low an operating frequency as possible for EME work.

On the other hand, the power gain of a beam antenna of a given *size* increases by the same ratio that the path loss increases and, because the antenna gain is realized in both transmission and reception, there is a net circuit signal gain with increase in frequency, even after deducting the increased circuit losses.

The various factors point to the use of the 144 MHz and 430 MHz Amateur bands for EME operation: good equipment is available, antenna size is not too great, and there's enough international activity on these bands to make the investment in time and effort worthwhile. On 2 meters, the

portion of the band between 144.00 and 144.10 MHz is an international segment, and it is in this region that a great deal of serious moonbounce activity takes place.

how much power? how big an antenna?

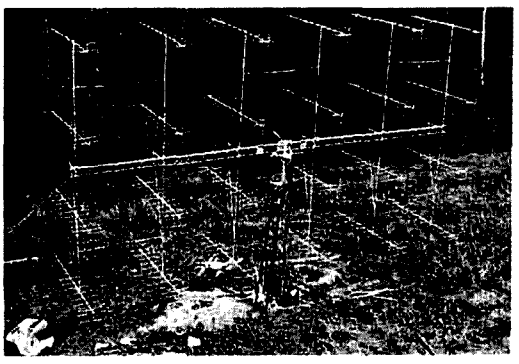
Fig. 4 provides a guideline to successful moonbounce communications. The scale at the right-hand side of the nomograph labeled Total Antenna Gain shows, for example, that if two stations having a combined antenna gain of about 43 dB and are satisfied with an average signal-to-noise ratio of zero dB, they can achieve two-way communications.

This graph is based upon a transmitter power output of 590 watts, a zero-dB noise figure, and a receiver bandwidth of 100 Hz. I'm sure that no moonbounce station fits these esoteric requirements, but hundreds of them come close, and some may surpass these figures. This is how it is done in the real world.

The Total Antenna Gain scale tells us that if one EME station is equipped with a 26-dB-gain antenna, the station at the other end of the circuit will need only 17 dB antenna gain, all other things being equal. *The greater the antenna gain at one end, the smaller the array needs to be at the other end.* On 2 meters, there are many stations equipped with high-gain antennas for meteor scatter and other forms of long-distance communication. Long Yagi beam antennas are available from several manufacturers, and many will provide a power gain of 17 dB. Two of them properly arranged can provide about 20 dB power gain. Again, all else being equal, a station equipped with a 20-dB antenna array can theoretically contact another station which has an antenna array with a power gain of 23 dB. And, if contacts are made on a rising or setting moon, the stations can take advantage of ground reflection of the signals to pick up an additional few dB of signal strength.

Moonbounce for everyone. That is just about possible using the new antenna recently assembled by Cushcraft's Chief Engineer, David Olean, K1WHS. Dave's antenna (below) makes it possible for him to contact stations with single Boomers and only modest power. Recently, he contacted Dave Redman, G4IDR, who was using a single Cushcraft 32-19 Boomer and approximately 200 watts at his antenna. Many other hams with single Yagis from Europe and the U.S. have had their first moonbounce contacts this year with K1WHS.

Dave Olean's new antenna consists of 24 Cushcraft Jr. Boomers model 214B. These Boomers are only 15 feet (4.6 m) long. The total antenna gain is about 26 dBd including feedline losses. This is more than sufficient to cover the 450,000 miles (725,000 km) round trip to and from the moon.



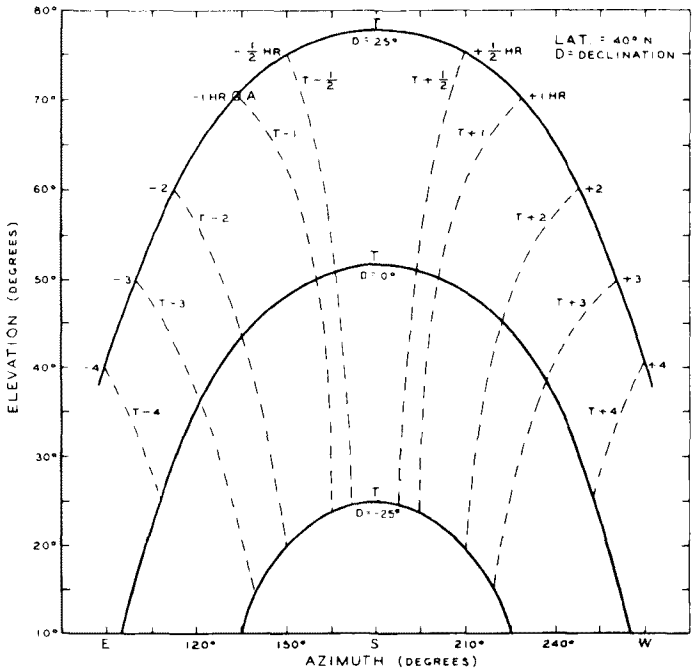


fig. 5. Moon position from center of U.S may be determined with this chart. The altitude of the moon above the horizon and its azimuth change minute by minute every day, but they repeat each lunar month. The "Nautical Almanac," or similar manuals, predict the moon position far in advance. This graph is plotted for a position of 40° North, with the observer facing south. At time T the moon is due south of the observer. At T-1 (one hour before T), the moon is at point A. Given the date, the declination, and the local time that the moon appears due south, the azimuth and elevation may be found. Curves for other values of declination can be interpolated and drawn in between these three curves. (Reference: Lund, "How High the Moon", *QST* July, 1965).

Today, stations using relatively modest antennas and everyday equipment are enjoying EME contacts on 2 meters. Many vhfers who have good antennas and high power are inadvertently bouncing their signals off the moon without even knowing it.

I recently spoke on the telephone with Dave Olean, K1WHS, who is a prominent 2-meter operator and well-known moon-bounce enthusiast. Dave has an elaborate antenna system, and tells me that he can aim his array at the moon and tune around 144.1 MHz during periods of high activity and hear Amateurs working each other. Their antennas are positioned so that the moon sweeps through the beam and their signals are reflected back to earth to the waiting ears of K1WHS. Dave guesses that there are probably over a thousand vhf stations in the United States who can work moonbounce but *don't know they have the capability*.

I asked Dave what it took to become an EME experimenter. He told me that if a station had a good 2-meter transceiver (such as the TS-700 Kenwood, or equivalent) a low-noise preamplifier, and a good, high-gain Yagi on a 15-foot boom, *he would hear* moonbounce signals, provided he aimed the antenna at the moon. Hearing signals is the first step to working stations.

the nitty-gritty

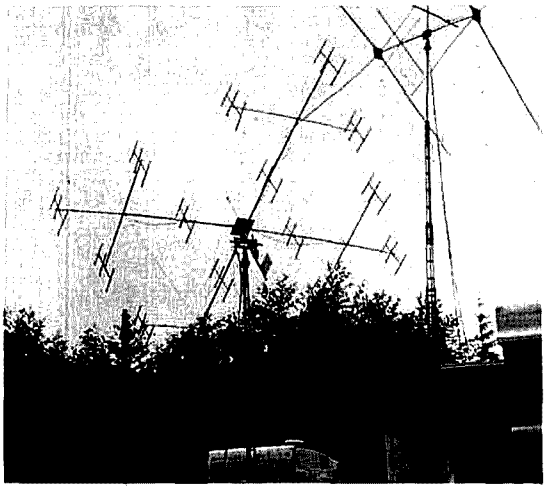
The nice thing about moonbounce is that you can let the other fellow do most of the work. The more antenna gain and power the other fellow has, the less you need. And there are enough serious-minded EME experimenters on the air today that a beginner can get in the game and talk to the big guns without having to make a large expenditure of time, money, or effort.

Of course, for the serious experimenter, there's a lot more to it than just hearing signals. Most moonbouncers have antennas that can track the moon — sometimes automatically. Computer-oriented Amateurs have complete tracking programs worked out showing the position of the moon a year in advance, and have antenna controls that permit automatic moon tracking. But you don't need all of this to get started. Many Amateurs have fixed antennas placed in such a position that the moon will sweep through the beam during the time the moon is mutually visible to operators at both ends of the chosen path. A typical moon-position chart, such as shown in **fig. 5** is useful in positioning the antenna.

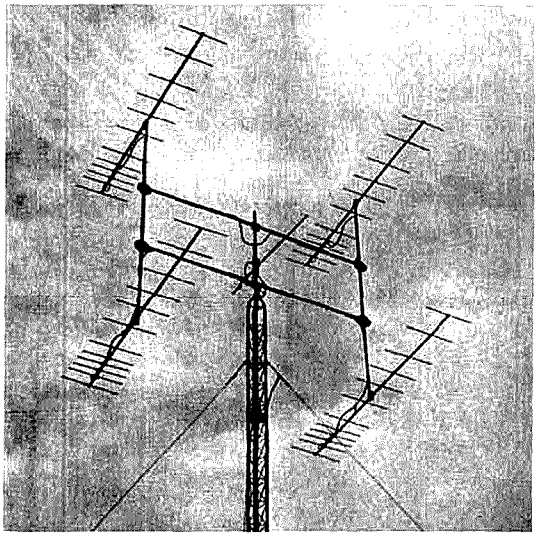
Other factors enter the picture, as the moonbouncer soon discovers. Because the moon moves toward or away from the earth at speeds up to 980 miles per hour, *Doppler shift* changes the frequency of the moon-reflected signal. At 144 MHz, the Doppler shift can be as large as 427 Hz. When the moon is rising, the received frequency goes up; when the moon is setting the frequency goes down. Frequency shift is minimum when the moon is perpendicular to the observer.

what does the signal sound like?

It takes a radio signal slightly over 2 seconds to make the trip to the moon and back, so the return echos of your transmission can be easily received. The best way of testing an EME cir-



The portable moonbounce station of K6YNB/KL7 (now N6NB) puts Alaska on the map. Note that the 2-meter array (left) is composed of sixteen 3-element quads.



Moonbounce array for 2 meters at WA1FFO is composed of four Yagis, each having 12 elements. All of these big antennas make it easier for you to work moonbounce because the other station does most of the work!



The radio telescope at Stanford University in California is occasionally used for moonbounce experiments in Amateur bands. You can really hear this 200-foot-diameter giant when it is on the air! The whole antenna and control building rotates on a circular metal track. Dominating the skyline above Palo Alto, California, the dish can be seen for miles.

cuit, in fact, is to listen to the return echos of your own transmitter. It is quite an eerie feeling to send CW signals and hear them bounce back at you a short time later. Voice signals returning from the moon have a hollow quality about them that is instantly recognizable to a moonbounce enthusiast.

Plenty of stations are active *today*. A good guess is that there are over 350 moonbounce stations active, in all continents, on the 2-meter and 432-MHz bands. Many of them maintain schedules with each other, but on an active weekend plenty of moonbouncers call CQ to raise another moon-bounce enthusiast. During an EME contest, or other weekend of high vhf activity, there is actually QRM among the many moonbounce signals.

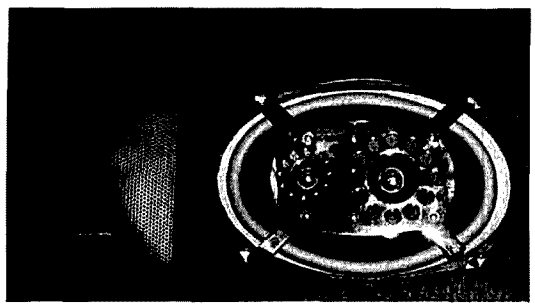
The second article in this series will carry more specific information about moonbounce equipment and activity for the 2-meter enthusiast. Suffice to say that if you have a high-gain Yagi antenna, a low-noise receiver, and sufficient know-how to aim your antenna to the moon, you could be hearing moonbounce signals before the next issue of this magazine reaches you.

If you want additional information about moonbounce, write to me and ask for the booklet "Almost Everything You Want To Know About Moonbounce." It is a reprint of important magazine articles on the subject. Send 30 cents in stamps to cover mailing to: William Orr, c/o EIMAC, 301 Industrial Way, San Carlos, California 94070.

references

1. The full story of John DeWitt is told in the May, 1946, issue of *QST* magazine, and also in the May, 1980, issue of *IEEE Spectrum*. The story of the first two-way Radio Amateur contact via the moon is told in the September, 1960, issue of *QST*.
2. Moonbounce contacts have been made on all Amateur bands between 50 and 2400 MHz. In addition, experimenters at Stanford University in California made moonbounce experiments in the 10-meter band using an array of log periodic antennas 1200 feet long and 75 feet wide.

ham radio



High-quality speakers make a big difference. Speaker is a Radio Shack *Minimus 7* (40 watts peak). Included are mounting brackets that could be used for under-dash mounting. A typical enclosure is shown at left.

better audio for mobile operation

Some suggestions for improved operating in your car

The concepts described in an earlier *ham radio* article[1] resulted in many letters to me. The same ideas in that article apply to mobile operation, only more so. When working mobile, you have outside road noise to contend with as well as ignition and other noises. Mobile rigs are now physically smaller; therefore the speakers are smaller, and so it goes. Regardless of speaker size, the audio systems in most of the mobile rigs are deficient.

When the audio gain control is turned up to overcome the various noises, the signal is distorted and most aren't loud enough, even if they aren't distorted. A few sets with small speakers in a small box have produced audio like you've never heard; so it is possible to get good audio from a small box.

loudspeakers

One approach to the mobile audio problem is to use a large speaker and mount it in the car headrest as shown. Lower volume levels are then needed, and this system works well. Use the largest speaker possible with a tweeter.

Another approach is to use a separate, low-level input, 12-volt audio amplifier connected to the top of the volume control as described in reference 1, with a built-in frequency equalizer to emphasize highs. You can also use an audio booster in conjunction with stereo fm cassette radios. The output of the ham rig can be connected in parallel with one channel or, preferably, switched with a dpdt switch. You then get the needed power gain and frequency-response control. Use high-quality, *large* speakers with mid- and high-range tweeters. My booster has a control to fade in two speakers in the front of the car. These speakers can be mounted under the seat, in the door, or in the ceiling headliner. The main stereo speakers are at the car rear, but the headrest speakers are much closer to your ear. You now will have a wide range of combinations, which produce beautiful and *understandable* audio with no distortion and shaped to your ears' deficiencies by the equalizer.

A suggested hookup is shown in **fig. 1**. I also use stereo earphones, parallel connected when used with the ham set. The new Sennheiser Model 420 is ideal, as it has an open earpiece and therefore doesn't block out road noises. These units are lightweight and can be used for long periods of time. They can, of course, be used with the stereo fm radio.

tone control

A welcome addition to any rig is a tone control that *emphasizes* the highs rather than attenuating them. The average person's ears are being bombarded with

By Ken Glanzer, K7GCO, 202 South 124 Street, Seattle, Washington 96168

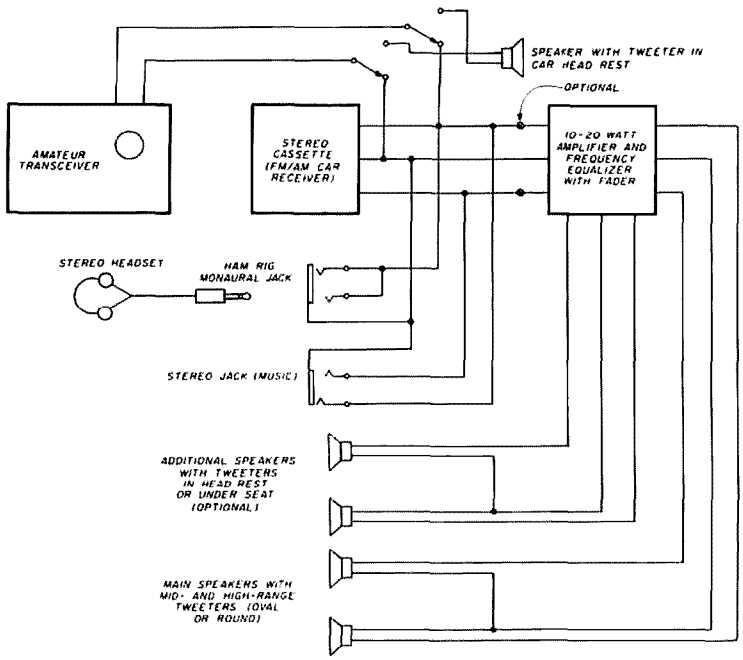


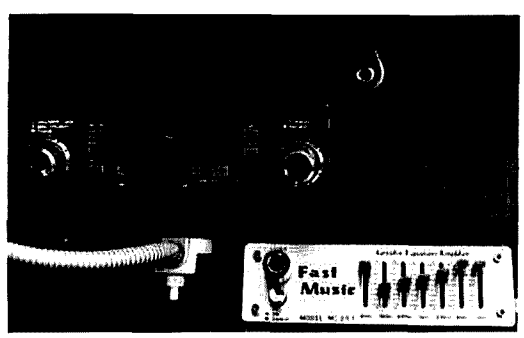
fig. 1. Basic setup for a near-ideal audio system in your car. Scheme features undistorted audio and plenty of volume for mobile operation.

high levels of noise; the loss of high-frequency response is occurring at an earlier age.

I frequently remove the capacitors between the base and collector in the final transistor audio stage, or any other component that cuts the highs. Or, I may alter the values of some components. Many have said, "I can understand what they say on your radio." Many Amateurs are not deaf from the standpoint of *level*, but are "tone deaf." They can't hear the high frequencies. Sometimes, a small tweeter can be installed near one ear with good results.



Speakers mounted in the car headrest brings them closer to your ears; less volume is needed. Stereo earphones, monaurally connected, and with open ear pieces, are comfortable for long listening periods and don't isolate you from outside noise (such as police sirens).



Stereo amplifier and frequency equalizer connect directly to speaker output of your ham rig and fill the car with clear, undistorted audio (with proper speaker). You can change frequency response for enhanced intelligibility.

reference

1. Ken Glanzer, K7GCO, "Better Audio for New or Old Communications Receivers," *ham radio*, April, 1977, page 74.

ham radio

repeater security

A combination lock using CMOS devices

The solution was a nonvolatile control. The problem was a secure, remote controlled electronic combination lock for the local repeater; one which would not forget if it was turned on or turned off if the power should fail momentarily, or if the supply line should suddenly become filled with electronic noise. With thoughts of security, simplicity, and ultra-low power drain in mind, the circuit shown here was devised.

features

The control, designed to operate in conjunction with standard TTL tone decoders, uses a sequence of three digits to effect the turn-on function and a different three digit sequence for turn-off. The digits must be applied precisely in the selected sequence to achieve the desired function. The turn-on process automatically prepares the control to accept the turn-off sequence and, similarly, the turn-off process prepares the control to accept the turn-on sequence. To safeguard against the possibility of electronically picking the combination lock, provisions were made to accept digits unused in either control sequence as reset inputs. The entire control uses four ICs, four transistors, and ten diodes.

circuit

Referring to fig. 1, the combination-lock function is accomplished by a series of D flip-flops. U1A, U1B, and U2A comprise the turn-on function, and U2B, U3A, and U3B comprise the turn-off function. Activation of either function is accomplished by clocking the flip-flop string in sequence. Beginning with U1A (or U2B), each flip-flop enables the succeeding one in the string by taking its D input to a high logic level. In this manner, U2A cannot be clocked until U1B has been clocked, which in turn cannot be clocked until U1A has been clocked. After completion of the turn-on sequence, in the proper order, the falling edge of U2A's $\overline{Q}$ output clocks the

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latch comprised by gates U4C and U4D to its ON state. This negative-going pulse also is inverted and coupled to the reset inputs of flip-flops U2B, U3A, and U3B, which prepares them for the turn-off sequence.

In the ON state, U4C output saturates the triple-darlington Q1, Q2, and Q3 through a 1 megohm resistor. The open collector output of Q1 may be used to control an external relay. The base lead of Q3 has been brought out on the printed-circuit board for the possibility of using an external master override for either the ON or OFF function.

The unused digit inputs are connected in OR fashion to Q4 through diodes CR1 through CR8. If any one of these inputs is selected, Q4 will saturate, taking one input of gates U4A and U4B to a logic zero level. This will reset both flip-flop strings to their zero state, thereby effecting the anti-picking feature by neutralizing any accidental progress made by non-authorized attempts to operate the control. Assuming different digits are selected for each sequence input, the odds against someone happening upon the proper combination for either control operation by chance are $16 \times 15 \times 14$ or 3,360 to 1 for a sixteen-button pad. The odds may be increased simply by adding additional data latches to the string.

Nonvolatility was achieved by designing the circuit for ultra-low power drain. All the ICs are CMOS, and the total supply current for all four chips is less than 1 microamp. The power hog in the unit is the base current required to saturate the triple-darlington. This current, 2.9 microamps, is esentially the total supply current drain when the control is on. With only the onboard 100 μF capacitor across the supply, the con-

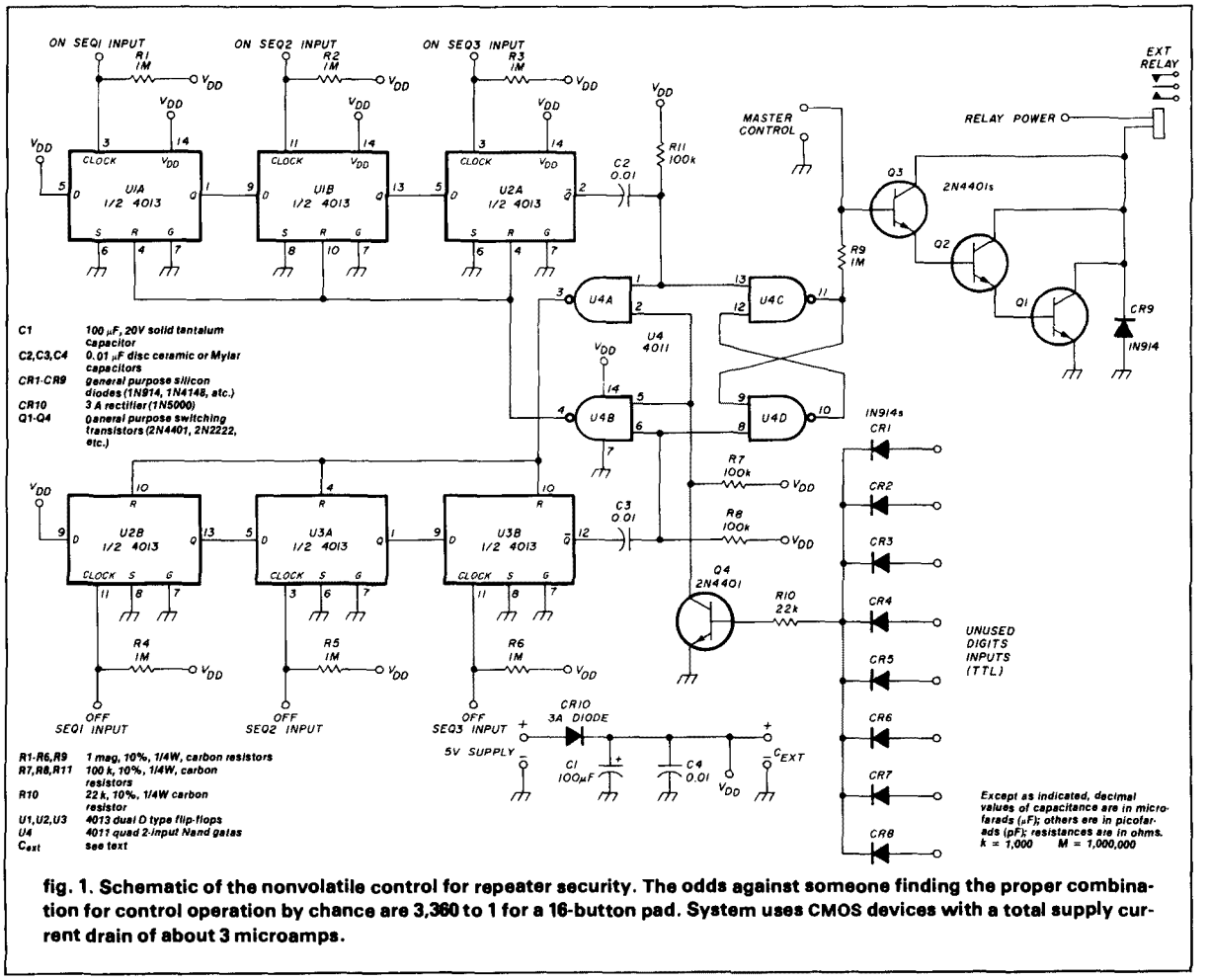


fig. 1. Schematic of the nonvolatile control for repeater security. The odds against someone finding the proper combination for control operation by chance are 3,360 to 1 for a 16-button pad. System uses CMOS devices with a total supply current drain of about 3 microamps.

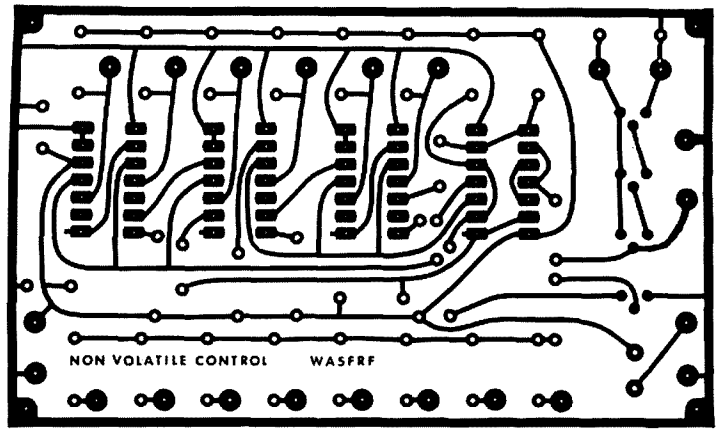


fig. 2. Single-sided PC board layout for the repeater control.

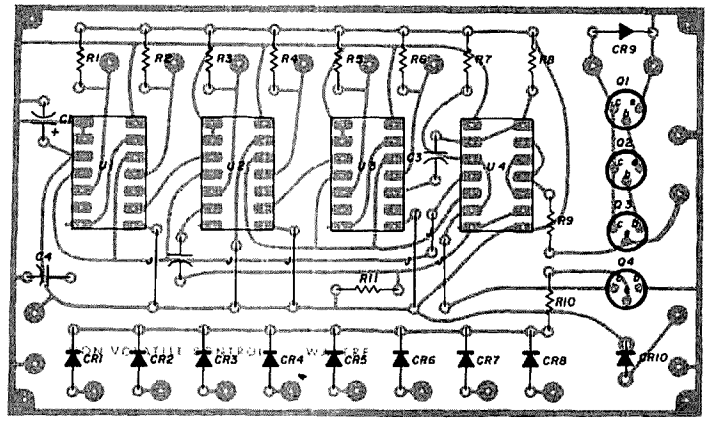


fig. 3. PC-board parts placement.

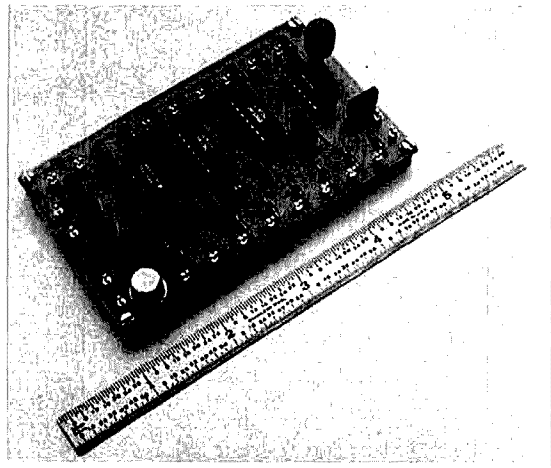


fig. 4. Photo of the completed control circuit.

trol will be nonvolatile for several minutes after power failure. This time may be extended to hours if a larger capacitor is supplied externally, or it may be extended indefinitely if an external battery pack is supplied. The control supply bus is isolated from the supply line by diode CR10. CR10, a 3-amp power rectifier, was chosen to withstand the charge-up current of the large supply bypass capacitor and also provides reverse supply protection. Supply voltage must be 5 volts if the unit is to be compatible with TTL tone decoders.

A single-sided printed circuit board layout for the control is shown in **fig. 2**. Component placement and a photograph of a completed board are in **figs.3** and **4** respectively. To maintain the ultra-low-power drain characteristics, the assembled board must be kept reasonably clean.

ham radio

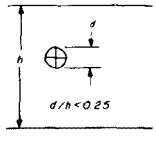
transmission-line circuit design

Using distributed resonant circuits for VHF/UHF transmission lines

Part 2 of this article, which appeared in the January, 1981, issue of *ham radio*, dealt with the geometry of the first four of twelve common transmission line configurations. In this, part 3 of the article, another set of four transmission line configurations will be examined: circular wire between planes, parallel wires over a plane, circular wire in an open trough, and parallel wires between planes/rectangular box.

Part 4 of this series will deal with the remaining four configurations. Part 5, the last in the series, will provide a summary of what has been discussed and show a design example for a 2-meter amplifier.

circular wire between planes



The formulation for the characteristic impedance of this line is similar to that for a single wire over a parallel plane (reference 4):

$$Z_0 = \frac{138}{\sqrt{\epsilon_r}} \log_{10} \frac{4h}{\pi d} \; ; \; d/h < 0.75 \qquad (25)$$

where Z_0 = line impedance (ohms)
ϵ_r = dielectric constant
h = distance between planes
d = wire diameter centered between planes

Fig. 12 shows Z_0 versus h/d for a reasonable range

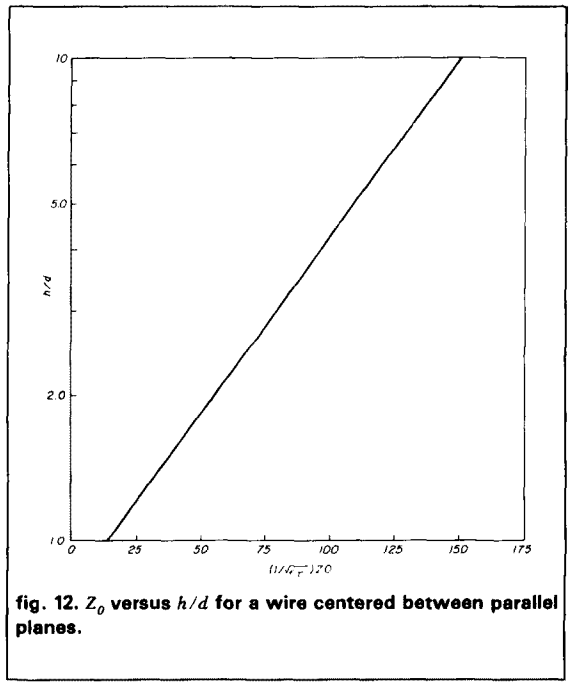


fig. 12. Z_0 versus h/d for a wire centered between parallel planes.

By H.M. Meyer, Jr., W6GGV, 29330 Whitley Collins Drive, Rancho Palos Verdes, California 90274

table 20. HP-67/97 program for calculating Z_0 and h/d for a wire centered between parallel planes.

step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code
001	*LBLA	21 11	030	3	03
002	STO0	35 00	031	8	08
003	$\sqrt{X}$	54	032	÷	−24
004	STO1	35 01	033	STO3	35 03
005	RTN	24	034	*LBL3	21 03
006	*LBLB	21 12	035	RCL1	36 01
007	÷	−24	036	X=0?	16-43
008	*LBL1	21 01	037	GSB8	23 08
009	STO2	35 02	038	x	−35
010	4	04	039	10^x	16 33
011	x	−35	040	4	04
012	Pi	16-24	041	÷	−24
013	÷	−24	042	Pi	16-24
014	LOG	16 32	043	x	−35
015	1	01	044	STO2	35 02
016	3	03	045	R/S	51
017	8	08	046	*LBLD	21 14
018	x	−35	047	GTO1	22 01
019	STO3	35 03	048	*LBL9	21 09
020	*LBL2	21 02	049	1	01
021	RCL1	36 01	050	STO1	35 01
022	X=0?	16-43	051	RCL3	36 03
023	GSB9	23 09	052	GTO2	22 02
024	÷	−24	053	*LBL8	21 08
025	STO4	35 04	054	1	01
026	R/S	51	055	STO1	35 01
027	*LBLC	21 13	056	RCL3	36 03
028	STO4	35 04	057	GTO3	22 03
029	1	01	058	R/S	51

of values. **Table 20** is the HP-67/97 program for calculating Z_0 or h/d or, given L and d separately, calculating Z_0. **Table 21** identifies the storage registers; **table 22** shows program control.

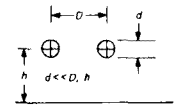
table 21. Register contents for HP-67/97 program for calculating Z_0 and h/d for a wire centered between parallel planes.

STO 0	ϵ_r
STO 1	$\sqrt{\epsilon_r}$
STO 2	h/d
STO 3	INTERIM
STO 4	Z_0

table 22. HP-67/97 program control for calculating Z_0 and h/d for a wire centered between parallel planes.

enter	ϵ_r	press A	
calculates	Z_0		
enter	h	press ENTER	
enter	d	press B	
calculates	h/d		Note: If no value for ϵ_r is entered, program assumes $\epsilon_r = 1 = air$.
enter	Z_0	press C	
calculates	Z_0		
enter	h/d	press D	

parallel wires over a plane



The common application of this line is for push-pull tank circuits with lines spaced much more closely to the ground plane than to the cover. The formulation (reference 4) is:

$$Z_0 = \frac{69}{\sqrt{\epsilon_r}} \log_{10} \left\{ \left(\frac{4h}{d}\right) \left[1 + \left(\frac{2h}{D}\right)^2\right]^{1/2} \right\} \quad d << D, h \qquad \textbf{(26)}$$

where Z_0 = line impedance (ohms)
ϵ_r = dielectric constant
h = centerline height of wires over plane
d = wire diameter
D = center-to-center spacing between wires

For analysis this equation may be reformulated to

$$Z_0 = \frac{69}{\sqrt{\epsilon_r}} \left\{ \log_{10} \frac{4h}{d} + \log_{10} \left[1 + \left(\frac{2h}{D}\right)^2\right]^{1/2} \right\} \qquad \textbf{(27)}$$

which permits solution if h/d and Z_0 are known, or if h/D and Z_0 are known.

When solving for h/D when Z_0 and h/d are known, **eq. 27** may be rearranged for easy solution on the HP-67/97 to

$$\log_{10} \left[1 + \left(\frac{2h}{D}\right)^2\right]^{1/2} = \left(\frac{Z_0 \sqrt{\epsilon_r}}{69}\right) - \log_{10} \left(\frac{4h}{d}\right) \qquad \textbf{(28)}$$

Eq. 28 is transposed when solving for h/d with Z_0 and h/D known.

Fig. 13 is a plot of Z_0 versus h/d for various values of h/D. **Table 23** provides an HP-67/97 program for calculating various combinations of knowns and unknowns. **Table 24** identifies the storage registers; **table 25** shows how the program is controlled.

table 23. HP-67/97 program for calculating Z_0, h/d, and h/D for two parallel wires over a plane.

step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code
001	*LBLA	21 11	029	9	09	057	10^x	16 33	085	9	09
002	STO0	35 00	030	x	−35	058	X^2	53	086	÷	−24
003	$\sqrt{X}$	54	031	STO5	35 05	059	1	01	087	RCL5	36 05
004	STO1	35 01	032	RCL1	36 01	060	−	−45	088	+	−55
005	RTN	24	033	X=0?	16-43	061	$\sqrt{X}$	54	089	10^x	16 33
006	*LBLB	21 12	034	GSB9	23 09	062	2	02	090	4	04
007	R↓	−31	035	÷	−24	063	÷	−24	091	÷	−24
008	÷	−24	036	STO6	35 06	064	STO3	35 03	092	STO4	35 04
009	STO2	35 02	037	R/S	51	065	R/S	51	093	R/S	51
010	1/X	52	038	*LBLC	21 13	066	*LBLD	21 14	094	*LBLE	21 15
011	STO3	35 03	039	STO4	35 04	067	STO3	35 03	095	STO3	35 03
012	R↓	−31	040	R↓	−31	068	R↓	−31	096	R↓	−31
013	÷	−24	041	STO6	35 06	069	STO6	35 06	097	STO4	35 04
014	STO4	35 04	042	RCL4	36 04	070	RCL3	36 03	098	GTO1	22 01
015	*LBL1	21 01	043	4	04	071	2	02	099	*LBL9	21 09
016	RCL3	36 03	044	x	−35	072	x	−35	100	1	01
017	2	02	045	LOG	16 32	073	X^2	53	101	STO1	35 01
018	x	−35	046	ST-5	35-45 05	074	1	01	102	RCL5	36 05
019	X^2	53	047	RCL1	36 01	075	+	−55	103	RCL1	36 01
020	1	01	048	X=0?	16-43	076	$\sqrt{X}$	54	104	RTN	24
021	+	−55	049	GSB8	23 08	077	LOG	16 32	105	*LBL8	21 08
022	$\sqrt{X}$	54	050	RCL6	36 06	078	ST-5	35-45 05	106	1	01
023	RCL4	35 04	051	x	−35	079	RCL1	36 01	107	STO1	35 01
024	4	04	052	6	06	080	X=0?	16-43	108	RTN	24
025	x	−35	053	9	09	081	GSB7	23 07	109	*LBL7	21 07
026	x	−35	054	÷	−24	082	RCL6	36 06	110	1	01
027	LOG	16 32	055	RCL5	36 05	083	x	−35	111	STO1	35 01
028	6	06	056	+	−55	084	6	06	112	RTN	24
									113	R/S	51

table 24. Register contents for HP-67/97 program for calculating Z_0, h/d, and h/D for two parallel wires over a plane.

STO 0	ϵ_r
STO 1	$\sqrt{\epsilon_r}$
STO 2	D/h
STO 3	h/D
STO 4	h/d
STO 5	INTERIM
STO 6	Z_0

table 25. HP-67/97 program control for calculating Z_0, h/d, and h/D for two parallel wires over a plane.

calculates	$\sqrt{\epsilon_r}$	
enter	ϵ_r	press A
calculates	Z_0	
enter	d	press ENTER
enter	D	press ENTER
enter	h	press ENTER
		press B
calculates	h/D	
enter	Z_0	press ENTER
enter	h/d	press C
calculates	h/d	
enter	Z_0	press ENTER
enter	h/D	press D
calculates	Z_0	
enter	h/d	press ENTER
enter	h/D	press E

Note: If no value for ϵ_r is entered, program assumes $\epsilon_r = 1 = air$.

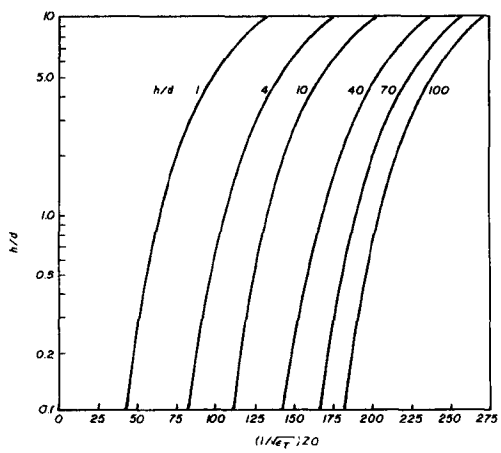
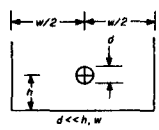


fig. 13. Z_0 versus h/D for values of h/d for two parallel wires over a plane.

circular wire in open trough



A common application of this configuration is in rf amplifiers, mixers, and local oscillator or multiplier filter elements at 100 MHz and above. The generalized formulation (reference 4) for a circular wire in an open trough is given by:

$$Z_0 = \frac{138}{\sqrt{\epsilon_r}} \log_{10}\left[\frac{4w \tanh\frac{\pi h}{w}}{\pi d}\right] \qquad (29)$$

for $d << h, w$

where Z_0 = line impedance (ohms)
ϵ_r = dielectric constant
d = wire diameter
h = centerline height of wire over plane
w = width of trough with wire positioned in center

The formulation can be simplified considerably if one assumes a square open trough where w (trough width) equals $2h$ (two times the centerline height of the wire over the bottom plane). The resulting formula for a square open trough is:

$$Z_0 = \frac{138}{\sqrt{\epsilon_r}} \log_{10}\left[\frac{8h}{\pi d} \tanh\frac{\pi}{2}\right] \qquad (30)$$

and

$$\tanh\frac{\pi}{2} = 1.0 \qquad (31)$$

then

$$Z_0 = \frac{138}{\sqrt{\epsilon_r}} \log_{10}\left[2.5465\frac{h}{d}\right] \qquad (32)$$

Fig. 14 shows h/d versus Z_0 for eq. 32. Table 26 is the HP-67/97 program for calculating Z_0 and h/d. Table 27 shows the registers used. Table 28 shows how the program is controlled.

Table 29 is the HP-67/97 program for calculating Z_0, h/w, and w/d given any two of the unknowns for any rectangular configuration, which is the general solution of eq. 29. Table 30 indicates the storage registers used in the program, and table 31 shows how the program is controlled. Fig. 15 is a plot of Z_0 versus w/d for various values of h/w from eq. 29. Note that eq. 29 is solved directly for Z_0 in table 29. If Z_0 and w/d are given, h/w is solved by using eqs. 33, 34, and 35. A similar variant is used if h/w is known and w/d must be calculated.

$$\frac{Z_0\sqrt{\epsilon_r}}{138} = \left(\log_{10}\frac{4w}{d}\right) + \left(\log_{10}\tanh\frac{\pi h}{w}\right), \qquad (33)$$

recognizing that

$$\tanh x = \frac{e^x - e^{-x}}{e^x + e^{-x}} \qquad (34)$$

and

$$\tanh^{-1} x = 1/2\, \ln\left[\frac{1+x}{1-x}\right] \qquad (35)$$

table 26. HP-67/97 program for calculating Z_0 and h/d for a circular wire in a square trough.

step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code
001	*LBLA	21 11	018	1	01
002	STO0	35 00	019	3	03
003	$\sqrt{x}$	54	020	8	08
004	STO1	35 01	021	x	−35
005	RTN	24	022	STO4	35 04
006	*LBLB	21 12	023	*LBL2	21 02
007	÷	−24	024	RCL1	36 01
008	STO2	35 02	025	X=0?	16-43
009	*LBL1	21 01	026	GSB9	23 09
010	2	02	027	÷	−24
011	.	−62	028	STO3	35 03
012	5	05	029	R/S	51
013	4	04	030	*LBLC	21 13
014	6	06	031	STO3	35 03
015	5	05	032	1	01
016	x	−35	033	3	03
017	LOG	16 32	034	8	08

table 26. HP-67/97 program for calculating Z_0 and h/d for a circular wire in a square trough (continued).

step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code
035	÷	−24	051	R/S	51
036	STO4	35 04	052	*LBLD	21 14
037	*LBL3	21 03	053	STO2	35 02
038	RCL1	36 01	054	GTO1	22 01
039	X=0?	16-43	055	*LBL9	21 09
040	GSB8	23 08	056	1	01
041	x	−35	057	STO1	35 01
042	10^x	16 33	058	RCL4	36 04
043	2	02	059	GTO2	22 02
044	.	−62	060	*LBL8	21 08
045	5	05	061	1	01
046	4	04	062	STO1	35 01
047	6	06	063	RCL4	36 04
048	5	05	064	GTO3	22 03
049	÷	−24	065	R/S	51
050	STO2	35 02			

table 27. Register contents for HP-67/97 program for calculating Z_0 and h/d for a circular wire in a square trough.

STO 0	ϵ_r
STO 1	$\sqrt{\epsilon_r}$
STO 2	h/d
STO 3	Z_0
STO 4	INTERIM

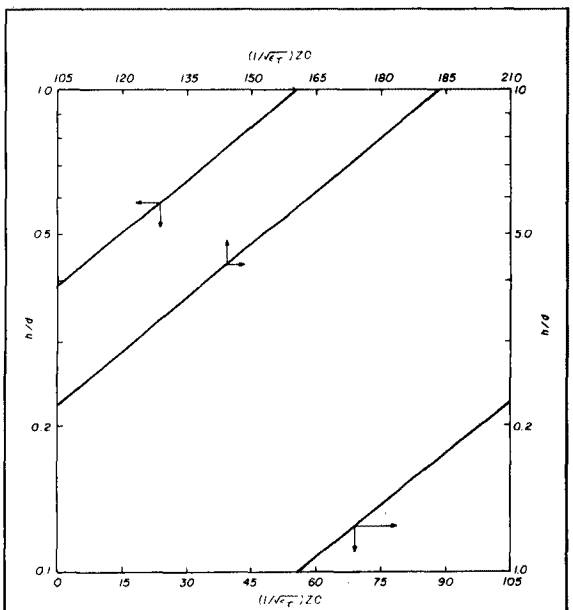


fig. 14. Z_0 and h/d for a circular wire in a square open trough.

table 28. HP-67/97 program control for calculating Z_0 and h/d for a circular wire in a square trough.

enter	ϵ_r	press A	
calculates	Z_0		
enter	h		
enter	d	press B	Note: If no value for ϵ_r is entered, program assumes $\epsilon_r = 1 = air$.
calculates	h/d		
enter	Z_0	press C	
calculates	Z_0		
enter	h/d	press D	

table 30. Register contents for HP-67/97 program for calculating Z_0, h/w, and w/d for a circular wire in a rectangular trough.

STO 0	ϵ_r	STO 6	$e^x + e^{-x}$
STO 1	$\sqrt{\epsilon_r}$	STO 7	$tanh\ \frac{\pi h}{w}$
STO 2	h/w		
STO 3	w/d	STO 8	INTERIM
STO 4	$\frac{\pi h}{w} = x$	STO 9	Z_0
		STO A	INTERIM
STO 5	$e^x - e^{-x}$	STO B	INTERIM

table 31. HP-67/97 program control for calculating Z_0, h/w, and w/d for a circular wire in a rectangular trough.

enter	ϵ_r	press A	
calculates	Z_0		
enter	d	press ENTER	
enter	h	press ENTER	
enter	w	press ENTER	
		press B	
calculates	h/w		Note: If no value for ϵ_r is entered, program assumes $\epsilon_r = 1 = air$.
enter	Z_0	press ENTER	
enter	w/d	press C	
calculates	w/d		
enter	Z_0	press ENTER	
enter	h/w	press D	

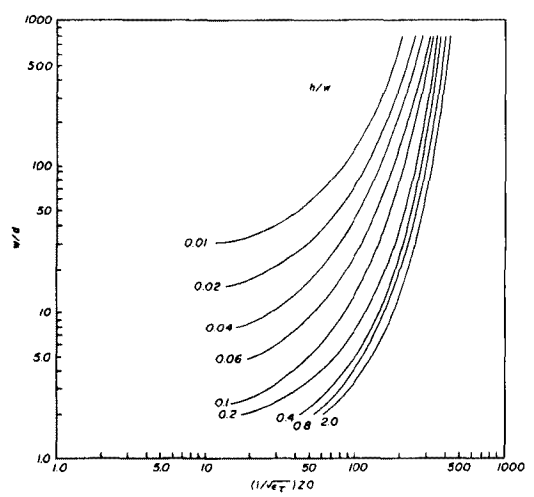
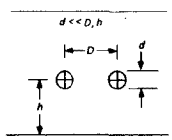


fig. 16. Z_0 versus w/d for various values of h/w of a circular wire in an open rectangular trough.

table 29. HP-67/97 program for calculating Z_0, h/w, and w/d for a circular wire in a rectangular trough.

step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code
001	*LBLA	21 11	039	Pi	16-24	077	÷	−24	115	STO4	35 04
002	STO0	35 00	040	÷	−24	078	Pi	16-24	116	e^x	33
003	$\sqrt{X}$	54	041	LOG	16 32	079	x	−35	117	STO5	35 05
004	STO1	35 01	042	1	01	080	STOA	35 11	118	RCL4	36 04
005	RTN	24	043	3	03	081	1	01	119	CHS	−22
006	*LBLB	21 12	044	8	08	082	+	−55	120	e^x	33
007	R↓	−31	045	x	−35	083	STOB	35 12	121	ST+5	35-55 05
008	÷	−24	046	STO8	35 08	084	RCLA	36 11	122	RCL4	36 04
009	STO2	35 02	047	*LBL1	21 01	085	CHS	−22	123	e^x	33
010	R↓	−31	048	RCL1	36 01	086	1	01	124	STO6	35 06
011	÷	−24	049	X=0?	16-43	087	+	−55	125	RCL4	36 04
012	STO3	35 03	050	GSB9	23 09	088	1/X	52	126	CHS	−22
013	*LBL1	21 01	051	x	−35	089	RCLB	36 12	127	e^x	33
014	RCL2	36 02	052	STO9	35 09	090	x	−35	128	ST-6	35-45 06
015	Pi	16-24	053	R/S	51	091	LN	32	129	RCL6	36 06
016	x	−35	054	*LBL9	21 09	092	2	02	130	RCL5	36 05
017	STO4	35 04	055	1	01	093	÷	−24	131	÷	−24
018	e^x	33	056	STO1	35 01	094	Pi	16-24	132	LOG	16 32
019	STO5	35 05	057	RCL8	36 08	095	÷	−24	133	CHS	−22
020	RCL4	36 04	058	RTN	24	096	STO2	35 02	134	ST+8	35-55 08
021	CHS	−22	059	*LBLC	21 13	097	R/S	51	135	RCL8	36 08
022	e^x	33	060	STO3	35 03	098	*LBLD	21 14	136	10^x	16 33
023	ST+5	35-55 05	061	R↓	−31	099	STO2	35 02	137	4	04
024	RCL4	36 04	062	STO9	35 09	100	R↓	−31	138	÷	−24
025	e^x	33	063	1	01	101	STO9	35 09	139	Pi	16-24
026	STO6	35 06	064	3	03	102	1	01	140	x	−35
027	RCL4	36 04	065	8	08	103	3	03	141	STO3	35 03
028	CHS	−22	066	÷	−24	104	8	08	142	R/S	51
029	e^x	33	067	STO8	35 08	105	÷	−24	143	*LBL8	21 08
030	ST-6	35-45 06	068	RCL1	36 01	106	STO8	35 08	144	1	01
031	RCL6	36 06	069	X=0?	16-43	107	RCL1	36 01	145	STO1	35 01
032	RCL5	36 05	070	GSB9	23 09	108	X=0?	16-43	146	RCL8	36 08
033	÷	−24	071	x	−35	109	GSB8	23 08	147	RCL1	36 01
034	STO7	35 07	072	10^x	16 33	110	x	−35	148	RTN	24
035	RCL3	36 03	073	RCL3	36 03	111	STO8	35 08	149	R/S	51
036	x	−35	074	1/X	52	112	RCL2	36 02	150	*LBLE	21 15
037	4	04	075	x	−35	113	Pi	16-24	151	STO2	35 02
038	x	−35	076	4	04	114	x	−35	152	R↓	−31
									153	STO3	35 03
									154	GTO1	22 01
									155	R/S	51

parallel wires between planes/ rectangular box



This configuration is often used for high-powered, push-pull amplifiers. Even though the formulation in eq. **36** does not consider the effects of side walls (only top and bottom planes), good results can be obtained if the lines are centered between the side walls and the distance from either wire to the side wall is at least greater than $h/2$, as shown in the sketch. A more exact formulation for balanced two-wire lines in a rectangular enclosure is given in reference 4 and discussed later in this section; however, it requires a rather tedious series of calculations.

The following formulation, also from reference 4, is based upon this relationship:

$$Z_0 = \frac{276}{\sqrt{\epsilon_r}} \log_{10}\left[\left(\frac{4h}{\pi d}\right)\left(\tanh\frac{\pi D}{2h}\right)\right] \quad \textbf{(36)}$$

For those who wish the exact relationship, it is given below from reference 4; the geometry is in **fig. 16.**

$$Z_0 = \frac{276}{\sqrt{\epsilon_r}} \left\{ \left[log_{10} \left(\frac{4h}{\pi d} \right) \left(tanh \frac{\pi D}{2h} \right) \right] - \sum_{m=1}^{\infty} log_{10} \left(\frac{1+U_m^2}{1-V_m^2} \right) \right\} \quad (37)$$

where Z_0 = line impedance (ohms)
ϵ_r = dielectric constant
h = spacing between planes with the lines centered
D = centerline distance between the lines
d = diameter of the lines (lines are assumed to be of equal diameter)

and

$$U_m = \frac{sinh \left(\frac{\pi D}{2h} \right)}{cosh \left(\frac{m\pi w}{2h} \right)} \quad (38)$$

$$V_m = \frac{sinh \left(\frac{\pi D}{2h} \right)}{sinh \left(\frac{m\pi w}{2h} \right)} \quad (39)$$

table 32. HP-67/97 program for calculating Z_0, h/d, and D/h for two parallel wires between planes/rectangular box.

step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code
001	*LBLA	21 11	039	R/S	51	077	÷	−24	115	RCL5	36 05
002	STO0	35 00	040	*LBLC	21 13	078	STO6	35 06	116	CHS	−22
003	$\sqrt{X}$	54	041	STO2	35 02	079	RCL1	36 01	117	e^x	33
004	STO1	35 01	042	R↓	−31	080	X=0?	16-43	118	−	−45
005	RTN	24	043	STO4	35 04	081	GSB8	23 08	119	RCL8	36 08
006	*LBLB	21 12	044	2	02	082	x	−35	120	÷	−24
007	R↓	−31	045	7	07	083	STO6	35 06	121	RTN	24
008	÷	−24	046	6	06	084	RCL3	36 03	122	*LBL8	21 08
009	STO2	35 02	047	÷	−24	085	4	04	123	1	01
010	R↓	−31	048	STO6	35 06	086	x	−35	124	STO1	35 01
011	÷	−24	049	RCL1	36 01	087	Pi	16-24	125	RCL6	36 06
012	STO3	35 03	050	X=0?	16-43	088	÷	−24	126	RCL1	36 01
013	*LBL1	21 01	051	GSB8	23 08	089	LOG	16 32	127	RTN	24
014	4	04	052	x	−35	090	ST-6	35-45 06	128	*LBL7	21 07
015	x	−35	053	STO6	35 06	091	RCL6	36 06	129	1	01
016	Pi	16-24	054	RCL2	36 02	092	X<0?	16-45	130	+	−55
017	÷	−24	055	Pi	16-24	093	GSB6	23 06	131	1	01
018	LOG	16 32	056	x	−35	094	10^x	16 33	132	RCL7	36 07
019	STO6	35 06	057	2	02	095	*LBL5	21 05	133	−	−45
020	RCL2	36 02	058	÷	−24	096	STO7	35 07	134	÷	−24
021	Pi	16-24	059	GSB9	23 09	097	GSB7	23 07	135	LN	32
022	x	−35	060	LOG	16 32	098	STO2	35 02	136	2	02
023	2	02	061	ST-6	35-45 06	099	R/S	51	137	÷	−24
024	÷	−24	062	RCL6	36 06	100	*LBLE	21 15	138	2	02
025	GSB9	23 09	063	10^x	16 33	101	STO2	35 02	139	x	−35
026	LOG	16 32	064	Pi	16-24	102	R↓	−31	140	Pi	16-24
027	ST+6	35-55 06	065	x	−35	103	STO3	35 03	141	÷	−24
028	RCL6	36 06	066	4	04	104	GTO1	22 01	142	STO2	35 02
029	2	02	067	÷	−24	105	*LBL9	21 09	143	RTN	24
030	7	07	068	STO3	35 03	106	STO5	35 05	144	*LBL6	21 06
031	6	06	069	R/S	51	107	e^x	33	145	CHS	−22
032	x	−35	070	*LBLD	21 14	108	RCL5	36 05	146	10^x	16 33
033	STO6	35 06	071	STO3	35 03	109	CHS	−22	147	1/X	52
034	RCL1	36 01	072	R↓	−31	110	e^x	33	148	GTO5	22 05
035	X=0?	16-43	073	STO4	35 04	111	+	−55	149	R/S	51
036	GSB8	23 08	074	2	02	112	STO8	35 08			
037	÷	−24	075	7	07	113	RCL5	36 05			
038	STO4	35 04	076	6	06	114	e^x	33			

Note that the open-sided equation (**eq. 36**) represents the maximum value of Z_0 that can be achieved with no side enclosure. The sum of the series in **eq. 37** reduces this value of Z_0 by the closing-in effect of the sides. As a consequence, if **eq. 37** and the charts and programs provided here are used, a conservative design will result, permitting the addition of more capacitance than the values calculated, as described in a previous section.

Fig. 17 shows the value of h/d plotted versus D/h for various values of Z_0. **Table 32** is the HP-67/97 program for calculating Z_0, D/h, or h/d depending on which variables are given. **Table 33** shows the registers used in the program, and **table 34** describes how the program is controlled.

A more simplified formulation for **eq. 36** is used in the program to permit calculation of the desired unknowns:

$$\frac{Z_0\sqrt{\epsilon_r}}{276} = \left(log_{10}\frac{4h}{\pi d}\right) + log_{10}\left(tanh\,\frac{\pi D}{2h}\right) \qquad \textbf{(40)}$$

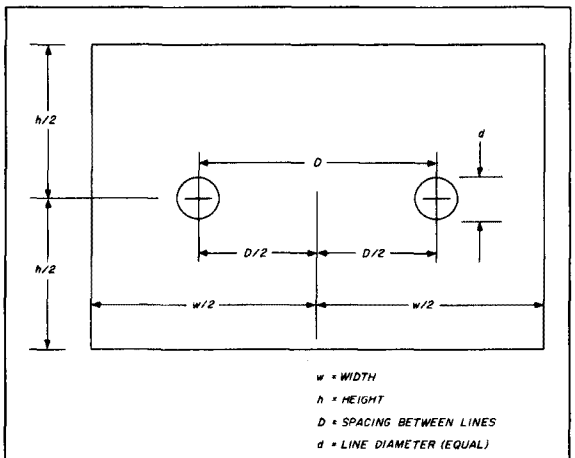


fig. 16. Geometry of balanced parallel lines in rectangular enclosure.

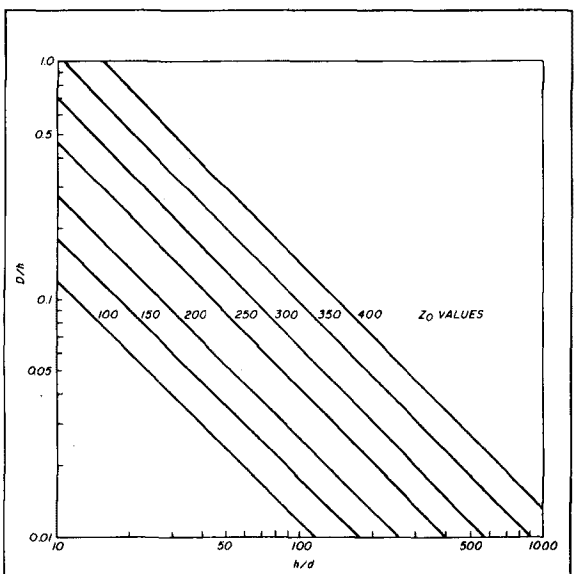


fig. 17. h/d versus D/h for various values of Z_0 for two parallel wires between planes.

table 33. Register contents for HP-67/97 program for calculating Z_0, h/d, and D/h for two parallel wires between planes/rectangular box.

STO 0	ϵ_r	STO 5	x for $tanh\,x$
STO 1	$\sqrt{\epsilon_r}$	STO 6	INTERIM
STO 2	D/h	STO 7	$tan^{-1}x$
STO 3	h/d	STO 8	INTERIM
STO 4	Z_0		

table 34. HP-67/97 program control for calculating Z_0, h/d, and D/h for two parallel wires between planes/rectangular box.

calculates	ϵ_r		
enter	ϵ_r	press A	
calculates	Z_0		
enter	d	press ENTER	
enter	D	press ENTER	
enter	h	press ENTER	
		press B	
calculates	h/d		
enter	Z_0	press ENTER	
enter	D/h	press C	Note: If no value for ϵ_r is entered, program assumes $\epsilon_r = 1 = air$.
calculates	D/h		
enter	Z_0	press ENTER	
enter	h/d	press D	
calculates	Z_0		
enter	h/d	press ENTER	
enter	d/h	press E	

In the next part of this article, part 4, the geometry and resonant-circuit design of the following configurations will be discussed: circular wire in a square shield, stripline over a plane, stripline centered between parallel planes, and helical resonators.

references

4. *Reference Data for Radio Engineers*, ITT Corporation, 5th Edition, 1968 (included in subsequent editions).

bibliography

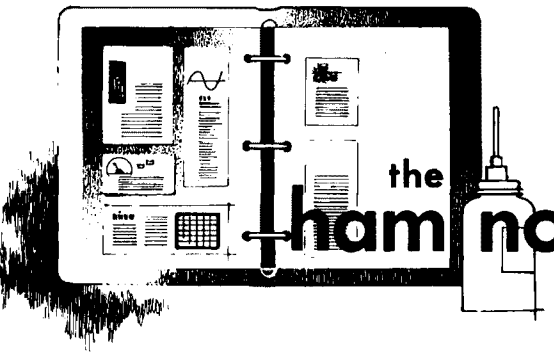
Bahl, Dr. K.J., "Use Exact Methods for Microstrip Design," *Microwaves*, December, 1978, pages 61-62.

Gardiol, F.E., "HP-65 Program computes Microstrip Impedance," *Microwaves*, December, 1977, pages 186-187.

"Letters to the Editor," *Microwave Systems News*, December, 1978, pages 13-14.

Murdock, B.K., *Handbook of Electronics Design and Analysis Procedures Using Programmable Calculators*, Van Nostrand Reinhold, 1979.

ham radio



computer control for the KLM antenna rotor

The most obvious approach to microprocessor control of antenna rotors does indeed work! In fig. 1 two CMOS quad-clocked D latches, U1, are connected in parallel to the first four least-significant digits of an input/output port of a computer. The computer enables first one, then the other latch, leaving behind an 8-bit word.

This byte, a number between 0-255, is converted through the classic "R-2R" network to a voltage between 0-5 volts. This voltage is compared with the voltage returning from the wiper of the potentiometer in the rotor housing.

The comparators turn on solid-state switches, which are connected across the clockwise and counter-clockwise front-panel switches on the rotor control box.

Thus the antenna will rotate in the direction that minimizes the difference between the two voltages.

The two 820k resistors provide a deadband so that when the proper heading is reached, the rotor will stop — not hunt.

Because the quad comparator, U2, loses all resemblance to a comparator as the inputs approach the upper rail, adjust the 15-turn pot, R, for a comparator input voltage of about 3.5 volts at full rotation. This voltage corresponds to a byte of 180. Then merely have the computer poke down to the latches a number between 0-180, which is one-half the required azimuth heading (or twice the required elevation).

The terminal numbers indicated in fig. 1 are for the KLM KR-400 and KR-500 rotors. Terminal 8 must be wired to the common connection of the two front-panel direction controls. Solid-state switches can be homebuilt with an opto-triac driver and triac, as in fig. 2.

This interface is very precise — four-degree resolution or better at most headings. The circuit will readjust for sudden wind gusts, voltage variations, etc., without complex software. The computer needs only to enter direction data every minute, say, using only a few machine cycles then go on to other work.

I conclude with a report of negative results: my first attempt at such an interface was with the new low-cost RCA CA3162E, two 4-bit magnitude comparators and four latches. The plan was to convert the rotor heading to digital information, then compare. Aside from problems with the multiplex timing of the 3162, this was a wasteful approach. At least ten comparators were at work instead of two!

C.R. Mac Cluer, W8MQW

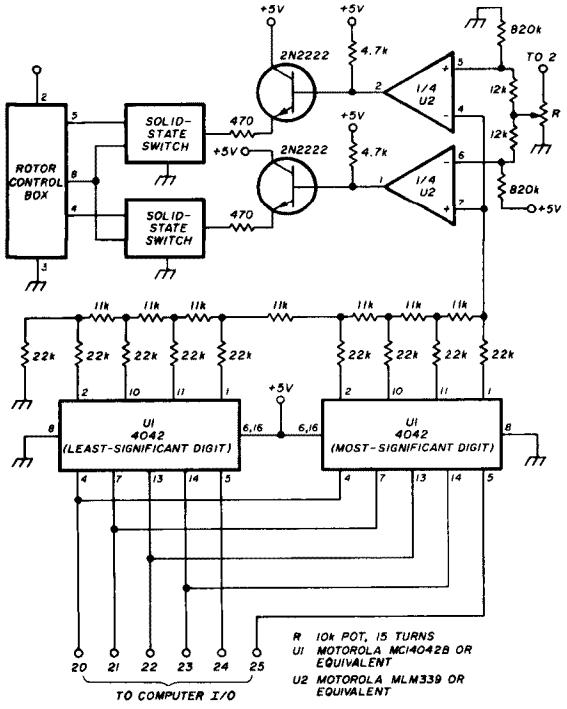
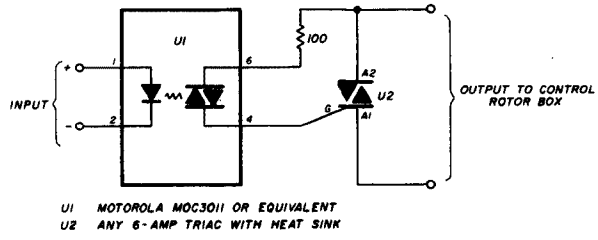


fig. 1, left: Interface circuit for microprocessor control of the KLM KR-400 and KR-500 antenna rotors.

fig. 2, below: Schematic of the solid-state switches, consisting of optically coupled triac driver and 6-ampere triac with heatsink.



varactor tuning tips

In tuning power varactor doublers, triplers, etc., there is often a sharp or sudden discontinuity in the tuning of one or more of the tuned circuits; a condition known as hysteresis.

While hysteresis is caused by some non-linearities in the diode function, it seems that it may also be a result of the circuit "Q" aggravating diode non-linearities. I figured that it might be possible to lessen the effect by a *reduction* in circuit "Q." Accordingly, I reduced the bias resistor in my 144-to-432 MHz tripler from 92 kilohms to about 12 kilohms. I was pleased to note that circuit performance was actually improved — tuneup was easier, and there was no appreciable loss of power output.

Richard N. Coan, N3GN

woodpecker noise blanker for the Drake TR-7 transceiver

If you have been reading the articles about the "Woodpecker Noise Blanker"[1] and wished your TR-7 could do the same to the "Russian Woodpecker," it can — with just two component changes. The Drake noise blanker for the TR-7 is functionally the same block diagram; the problem is that the one-shot and integrator time constants aren't set up for the Woodpecker.

I increased C831 from 0.001 μF to 0.01 μF and the one-shot capacitor from 0.01 μF to 0.1 μF. The results were fair to good. A 10-20 dB over S9 Woodpecker signal would be cut back to S5-6 with no real distortion to SSB, CW, or RTTY. I called Drake about the idea, but they have also made a change which will be in new NB7s to be sold soon. Their results were about the same as regards attenuation of the Woodpecker signal. Drake sent me a copy of their changes and I'll compare it with what I've done.

The noise blanker works best on strong Woodpecker signals (over S7). I have received three Woodpeckers each with its own signature. All have the same rate of 100 milliseconds (probably due to a division of the 50-Hz power line) but differ in pulse width and rise time.

The changes are simple and not critical. The only problem is that in my service manual, the pictorial didn't show the position of C840. Fig. 3 shows the area of the schematic where the changes are made, and fig. 4 shows the pictorial of the components to be changed.

I would like to thank W1IHN for allowing me to use his noise blanker to test this idea.

reference

1. Ulrich L. Rohde, DJ2LR, "Woodpecker Noise Blanker," *ham radio*, June, 1980, page 18.

John Bird, K1KSY

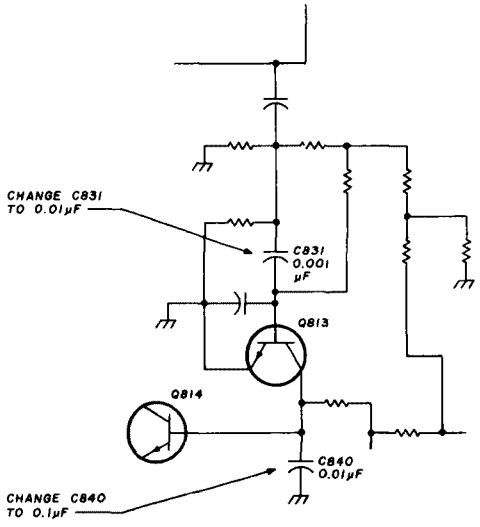


Fig. 3

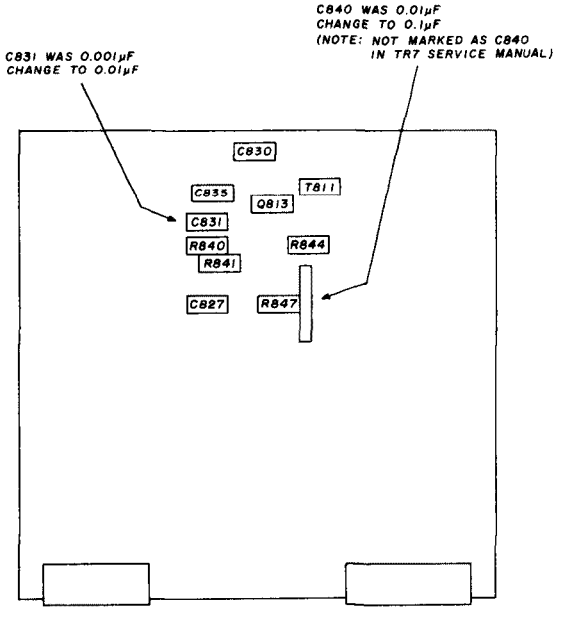


Fig. 4

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COLORADO: The Grand Mesa Repeater Society's second annual Western Slope Swapfest on March 7th at the Lincoln Park Barn, 12th and Gunnison, Grand Junction, Colorado. 10:00 AM through 4:00 PM FREE! Tables are $4.00 in advance. Commercial exhibitors, flea market, auction and prizes. Talk-in on 146.22/.82. More info: SASE to Larry Brooks, WB0ECV, 3185 Bunting Ave., Grand Junction, Colorado 81501. (303) 434-5603.

FLORIDA: The Treasure Coast Hamfest on February 21 and 22 at the Vero Beach Community Center. Admission: $3.00 per family in advance and $4.00 at the door. Talk-in on 146.13/73, 146.04/64, 146.52/52, 222.34/223.94. More info: P.O. Box 3088, Beach Station, Vero Beach, FL 32960.

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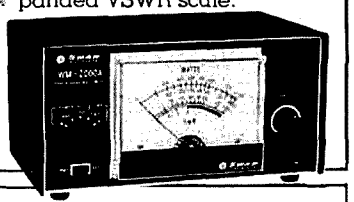
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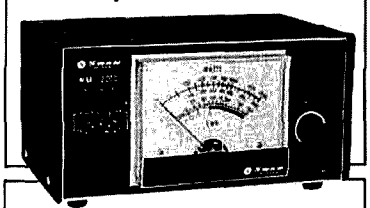
SWAN METERS

THE TOP OF THE LINE

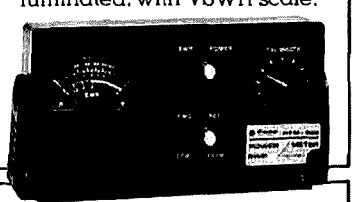
PEAK READING WATT METER WM-2000A reads power in 200, 1000, 2000 watt ranges. 3.5-30 MHz. Reads average or PEP power output. Includes expanded VSWR scale.



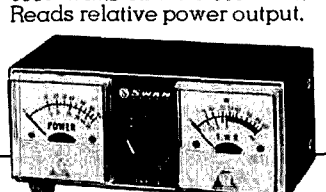
IN-LINE WATT METER WM-2000 reads power in 200, 1000, 2000 watts. 3.5-30 MHz. Incl. expanded VSWR scale.



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ILLINOIS: Sterling/Rock Falls Amateur Radio Society's 21st annual Hamfest on March 8 at the Sterling High School Field House, 1608 4th Ave., Sterling, Illinois. Flea market, free parking, many prizes, and much more. Doors open at 7:30 AM. For advance tickets and tables write: Sue Peters, 511-8th Ave., Sterling, Illinois 61081. Tickets in advance: $2.00. At the door: $2.50. Commercial tables are $5.00 and all others are $3.00. Talk-in on .52 and WR9AER .25/85.

OHIO: Intercity Amateur Radio Club's Mansfield Mid * Winter Hamfest/Auction on February 15th at the Richland County Fairgrounds in Mansfield. Prizes, flea market, large heated building and more. Starts at 8:00 AM. Talk-in on 146.34/.94. Tickets: $1.50 in advance and $2.00 at the door. More info, tickets, and/or tables: SASE, Harry Frietchen, 120 Homewood Rd., Mansfield, Ohio 44906. (419) 529-2801.

VIRGINIA: The Vienna Wireless Society, Vienna, Virginia, announces the annual WINTERFEST™ hamfest to take place this year on February 22, 1981. It will be held at the usual place, the Vienna Community Center on Park St. in Vienna, VA beginning at 8 AM.

WEST VIRGINIA: The Plateau Amateur Radio Association's 3rd annual Hamfest on February 15th at the Memorial Building in Fayetteville. Doors open at 9:00 AM. Admission: $2.50 (children free) and flea market tables are $2.00. Hot food, free parking, A.R.R.L. display, forums, exhibits, door prizes, XYL programs, and more. All activities indoors. Talk-in on .52 or .19/79. More info: Bill Wilson, 302 Central Ave., Apt. #2, Oak Hill, WV 25901. (304) 469-9910 or 574-1176.

IOWA: The Davenport Radio Amateur Club's tenth annual Hamfest on March 1st at the Davenport Masonic Temple at 7th and Brady (Hwy. 61) from 8:00 AM to 4:00 PM. Over $2000.00 in major prizes. Tickets in advance are $2.00 and $3.00 at the door. Talk-in on the W0BXR/RPT at 146.28/.88. Hotel discounts available. Food and drink. Pre-Hamfest Saturday night banquet with guest speaker Paul Grauer, midwest A.R.R.L., S.C.M. Banquet tickets: $8.00. Paid reservations for banquet by February 18th. For advance tickets, dinner, table reservations or info: Dave Johannsen, 2131 Myrtle, Davenport, Iowa 52804.

MICHIGAN: The 11th annual Livonia Amateur Radio Club's Swap 'n Shop on February 22 from 8:00 AM to 4:00 PM at the Churchill High School in Livonia. Plenty of tables, door prizes, refreshments and free parking. Talk-in on 146.52 simplex. Reserved table space available. More info: send SASE (4x9) to Neil Coffin, c/o Livonia A.R.C., P.O. Box 2111, Livonia, Michigan 48150.

MISSOURI: The Jefferson Barracks Amateur Radio Club's annual auction and Hamfest on March 13th at the Electricians Hall, 5850 Elizabeth Ave., St. Louis. More info: SASE Vivian K. Scott, WD0EMS, 4121 Fabian Dr., St. Louis, Missouri 63125.

NEW JERSEY: The Delaware Valley Radio Association's ninth annual flea market on March 15th at the New Jersey National Guard 112th Field Artillery Armory, Eggerts Crossing Rd., Lawrence Township. Advance tickets: $2.00, $2.50 at the gate. Indoor/outdoor flea market, prizes, refreshments and more. Talk-in on 146.07/67 and 146.53. More info or tickets: DVRA, P.O. Box 7024, West Trenton, NJ 08628. SASE please.

NEW JERSEY: Annual Flemington, N.J. Hamfest Saturday, March 21 from 8:30 to 3:00 at the Hunterdon Central High School Field House. 20,000 square feet of heated indoor area. Gigantic flea market, 200 tables, major manufacturers, informative seminars. Bring the XYL, kids and friends. Flemington is a tourist area. Talk in 146.52, 147.375, 147.015, 224.12. Admission $3.00 donation. For reservations or info call 201-788-4080 or write Cherryville Repeater Assn. c/o W2FCW, Box 76, Farview Ave., Annandale, N.J. 08801.

INDIANA: The LaPorte ARC's "Winter Hamfest" on February 22 at the LaPorte Civic Auditorium, 50 miles southeast of Chicago. Donations: $2.50 at gate and $2.00 in advance. Talk-in on .01/.61 and .52 simplex. More info: LPARC, Box 30, LaPorte, Indiana 46350.

OPERATING EVENTS

FEBRUARY 14 and 15 starts off the phone portion of the YL-OM contest. The CW segment will be on February 28 through March 1. Both contests start and end at 1800 UTC. They are to be treated separately and separate logs are to be kept. OMs call "CQ YL" and YLs call "CQ OM". All logs must show ARRL section or country to qualify and must be signed by the operator. No logs will be returned. Logs must show claimed score and be sent to YLRL Vice President, Kay Eyman, WA0WOF, RR #2, Garnett, KS 66032 no later than April 6. Duplicates penalized by the removal of three contacts.



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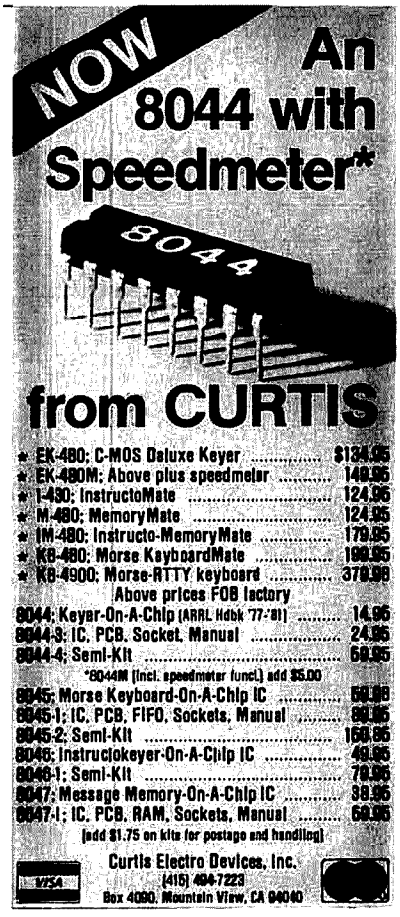
OCTOBER 23, 1980 - OCTOBER 23, 1981: The New Bern Amateur Radio Club is sponsoring "The Swiss Bear Award." This award is given for working three different amateur stations in the New Bern area within the above time period. Extracts from logs for QSO's, along with a SASE or two IRC's (for DX stations) should be sent to: New Bern Amateur Radio Club, Inc., P.O. Box 2483, New Bern, NC 28560. Certificate depicting "The Swiss Bear" will be awarded stating that the station has met the requirements for this award.

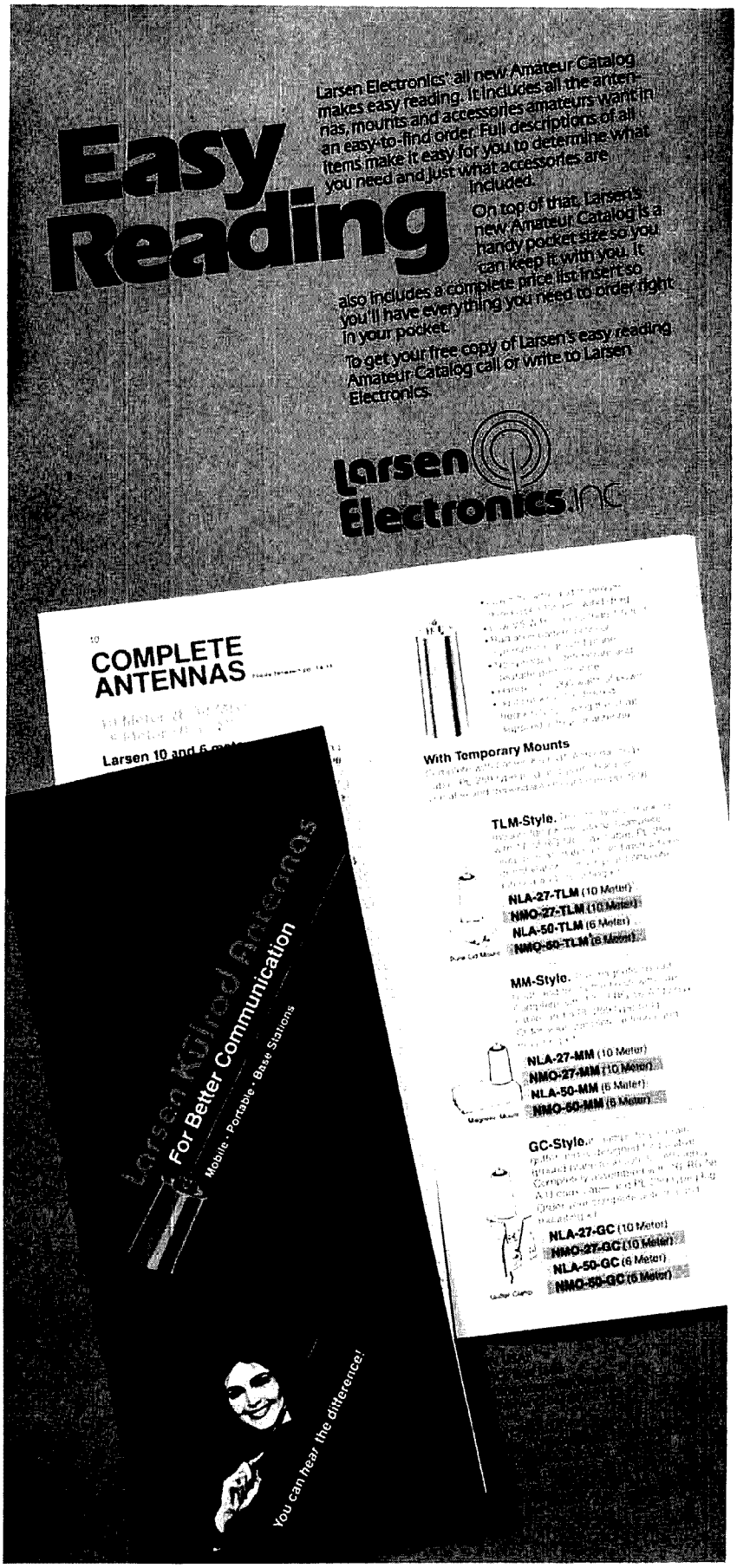
FEBRUARY 22nd - 28th: The Simon Langton Grammar Schools in Canterbury, England, will be celebrating the 100th anniversary of the founding of the school in 1881. A special events station, active on all HF bands under the call GB4SLS, will be used. It is hoped that many past pupils of the school will be contacted; especially licensed Amateurs now residing in the United States. Anyone interested in making a sked should contact: G4BBW, 40 Virginia Rd., Tankerton, Whitstable, Kent or G3LCK c/o G3OSL, Simon Langton Grammar School for Boys, Nackington Rd., Canterbury, Kent, England.

MARCH 14th: The Edison Radio Amateur's Association is celebrating its 40th anniversary by hosting a QSO party. The ERAA group will operate from a commemorative station at "Station A" in Greenfield Village, Dearborn, Michigan. This was Thomas Edison's first power generating station. Contact ERAA and exchange signal report state info. QSL with business size SASE and receive a handsome two color certificate to: Detroit Edison Radio Amateur's Association, 2000 Second Ave., Detroit, Michigan 48226.

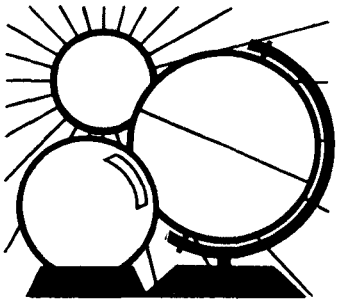
MARCH 14th: The Playground Amateur Radio Club (PARC) of Fort Walton Beach, Florida, will operate a special event station at the 1981 Boy Scouts of America — Choctawhatchee District Scout Exhibition. PARC members will operate ARS WB4SFU (Scouts For Unity) from 0000 to 2400 hrs UTC, 14 March, 1981 on 14.290 MHz, 21.370 MHz, and 28.600 MHz SSB. A special commemorative QSL card will be sent to those who QSL with a SASE. The QSL manager is PARC, c/o Joe Giangrosso, WD4JZG, P.O. Box 3075, Fort Walton Beach, FL 32548.

CENTURY 21 ARC — Low power — QRP'ers — CW nets — Contests — Awards — SASE KA4EBW.





More Details? CHECK—OFF Page 98



DX FORECASTER

Garth Stonehocker, KØRYW

predictions

We are still in the good old winter DX months with February; expect, however, a couple of periods of short-lived geomagnetic disturbances from solar flares about February 19-21 and February 27-March 4. Another longer-lasting period of disturbance may be expected near February 2-6. The best DX periods are probably about February 7-10 and 22-27.

a look at February

February is the month when changes in the ionosphere portend leaving the winter DX conditions of November, December, and January behind. Longer days are beginning to be seen as earlier sunrises and later sunsets in the northern hemisphere. The 10, 15, and 20 meter bands can be expected to open sooner in the morning and stay open longer into the evening. On the 40, 80, and 160 meter bands, which depend on darkness for their openings, the DX hours can be expected to begin to shrink. The DXer's evening schedule has to wait for sunset. The earlier sunrise decreases the S-meter readings of the long-skip DX, and exchanges it for short skip to the locals. Still, there are many hours in which to take advantage of the superb winter DX.

February is often the month with the highest mean solar radio flux values of the year. This is a long-lasting, averaging effect of the earth's being closer to the sun this time of year, and the winter months of November, December, and January being geomagnetically the quietest of the year. The combined result is that the ionosphere usually supports the highest daytime high-frequency and vhf DX paths of the year for many of the years of any particular eleven-year solar cycle.

The moon is at perigee on February 9. An annular eclipse of the sun takes place for our down-under and South-Pacific friends. The annular path (maximum duration is 1 minute 11 seconds) goes from the Island of Tasmania south of Australia at sunrise (1928 UT), then south of New Zealand, and across the South Pacific almost to Peru at sunset (0049 UT). The eclipse will be seen across the east side of Australia, across Antarctica (McMurdo from 2110 to 2220 UT), and from Chile, Argentina, Peru and Central America at its end. All this goes on from February 4 (1928 UT) to 5 (0049 UT).

band-by-band summary

Six meters will open occasionally toward Europe, that is, to the east, before *noon*, toward the south during noontime to afternoon, and toward the west and northwest in the late afternoon into early evening. The best openings are most likely trans-equatorial during high solar radio flux.

Ten and Fifteen meters will exhibit the same pattern as 6 meters but will be open a longer part of the day. This is particularly true this month since it is nearing springtime with its noticeably longer days and its probably higher maximum usable frequencies from higher solar flux. Short skip (500 to 1500 miles) is part of the fun on these bands, like the lower frequency bands. The short-skip opening pattern, although closer to mid-day, is the same follow-the-sun sequence as mentioned for 6 meters.

Twenty meters is a great band for everyone's pleasure, limited only by QRM. It should be open nearly every day and late into each evening to almost every part of the world. Best DX conditions can be expected just after sunrise *and* just *before sunset for* long skip. Short skip will be essentially as given for 10 and 15 meters, except for longer openings during midday.

Forty meters begins its transition into a night band. Short skip during the daytime in winter, however, gives some interesting opportunities for working your close neighbors for the WAS certificate. Then, at evening time, as the long skip (1000 to 2500 miles) develops, reach out for the far states and the WAC certificate. This band is very active to most areas of the world. In late afternoon the band will open to Europe, then swing around to South Africa and Central and South America, and then swing still farther into the Pacific by dawn.

Eighty and One-Sixty meters DX conditions will be very good this month. Soon the atmospheric noise of the spring storms will give days of short skip QRN and local QRN. On toward summer the static will become so bad that DX will have to be forgotten until fall. Take advantage of what's left of this year's quiet winter season. The directional pattern for these bands is similar to that of 40 meters. The low take-off angle of vertical antennas is very useful for DX here. Horizontal antennas are mainly short skip, high-take-off-angle radiators because of being so close to the ground. Look for particularly interesting DX as these bands come in (open) near sunset and go out at sunrise.

ham radio

WESTERN USA

GMT	PST	N	NE	E	SE	S	SW	W	NW
0000		10	—	15	10	15	10	10	10
0100		10	—	15	10	15	10	10	10
0200		10	—	15	10	15	10	10	10
0300		10	—	20	15	15	10	10	10
0400		15	40	20	15	15	10	10	15*
0500		15	40	20	20	15	15*	15	15
0600		20	40	20	20	15	15	15	20*
0700		20	40	20	20	20	15	15	20
0800		—	20	20	20	20	15	20	20
0900	1:00	—	20	—	20	20	20	20	40
1000	2:00	—	20	—	20	20	20	20	40
1100	3:00	—	20	—	20	40	20	20	20
1200	4:00	—	—	—	20	40	20	20	20
1300	5:00	—	—	—	40*	40	40	40	40
1400	6:00	—	—	15	20	40	40*	40	40*
1500	7:00	—	15	10	10	80	20	20	20
1600	8:00	20	10	10	10	—	15	20	20
1700	9:00	20	10	10	10	—	15	15	20
1800	10:00	20*	10	10	10	—	10	15	20
1900	11:00	20	15	10	10	—	10	15	20
2000	12:00	20	20*	10	10	—	10	10	—
2100		15	20	10	10	—	10	10	15
2200		15	20	10	10	—	10	10	10
2300		10	20	10	10	—	10	10	10
FEBRUARY		ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN

MID USA

MST	N	NE	E	SE	S	SW	W	NW	CST
	10	20	15	10	15	10	10	10	
	10	20	15	10	15	10	10	10	
	10	20	20	15*	15	10	10	10	
	10	40*	20	15	15	10	10	15	
	15	40	20	15	20	15*	15*	15	
	15	40	20	20*	20	15	15	15	
	20	40	20	20	20	15	20	20*	
	20	40	—	20	20	15	20	20	1:00
1:00	—	40	—	20	20	20	20	20	2:00
2:00	—	—	—	20	20	20	40	20	3:00
3:00	—	—	—	20	20	20	40	20	4:00
4:00	—	—	—	40*	40	20	20	—	5:00
5:00	—	20	—	20	40	20	40	—	6:00
6:00	—	15	20*	20*	40	20	40*	—	7:00
7:00	—	15*	10	10	20	20	20	20	8:00
8:00	—	10	10	10	—	20	20*	20	9:00
9:00	20	10	10	10	—	15	15	20	10:00
10:00	20	10	10	10	—	15*	15	20	11:00
11:00	20*	10	10	10	—	10	15	20	12:00
12:00	20	15	10	10	—	10	15	—	
	20	15	10	10	—	10	10	—	
	15	15	10	10	—	10	10	20*	
	15	20	10	10	15	10	10	10	
	10	20	15	10	15	10	10	10	
	ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN	

EASTERN USA

EST	N	NE	E	SE	S	SW	W	NW
	15*	20	15	10	15	10	10	15*
	15	20	15	10	20	10	10	15
	15	20	20*	15*	20	10	10	15
	20	40	20	15	20	15	15	20*
	—	40	20	15	20	15	15	20
	—	40	20	15	20	15	—	20
1:00	—	40	20	20	20	15	20	20
2:00	—	40	—	20	20	20	20	20
3:00	—	40	—	20	20	20	20	20
4:00	—	40	—	40	20	20	20	20
5:00	—	20	—	40	40	40	40	20
6:00	—	20*	—	20	40	80*	40	—
7:00	20	15	10	10	20	80*	20	—
8:00	20	20	10	10	—	20	20	20
9:00	20	10	10	10	—	20	15	20
10:00	20	10	10	10	—	15	15	20
11:00	20*	10	10	10	—	15	20	—
12:00	20	10	10	10	—	15*	20	—
	—	10	10	10	—	10	—	—
	—	15	10	10	—	10	—	—
	—	15	10	10	15	10	10	20
	—	15	10	10	15	10	10	20*
	20	20*	15	10	15	10	10	10
	20*	20	15	10	15	10	10	15*
	ASIA FAR EAST	EUROPE	S. AFRICA	CARIBBEAN S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN

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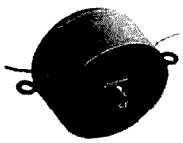
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short circuits

regulated power supply

The following corrections should be made to the schematic on page 58 of the September, 1980, issue of *ham radio*: M2 is 0-10 amps dc; C1 is 100 μF; C2 is a 0.01-μF/100-volt disc ceramic; the capacitor at pin 9 of U1 is 500 pF/100V paper/Mylar.

quads and quagis

In W2PV's quads and quagis article, which appeared in the September, 1980, issue of *ham radio*, **fig. 2** on page 38 should be turned 90 degrees to correspond with the caption. On page 45, in the last line of item two in the summary, the ratio should be expressed as width to height (W/H).

measuring inductance and capacitance

The Ham Notetook item on this subject by W2CHO that appeared on page 68 of the July issue should have included this equation:

$$LC = \frac{1000}{(2\pi)^2}\left(\frac{1}{f^2} - \frac{1}{f_0^2}\right)$$

digital logic probe

In **fig. 5** of N6UE's digital logic probe article (*ham radio*, August 1980), pin 1 of U1 (not pin 16) goes to V_{DD}. In **fig. 6** there should be traces from the emitter of Q1 to ground, from V_{CC} to the collector of Q2, and from the collector of Q1 to pin 2 of Q2.

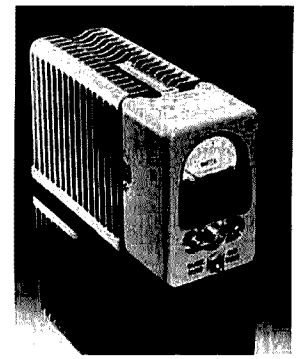
CW regenerator

The values of two capacitors are incorrect as printed in W3BYM's article (October, 1980, *ham radio*). C3 should have a value of 2.2 μF, C4 a value of 1.0 μF.

super quad

The boom pictured in **fig. 4** of W3NZ's article (November, 1980, *ham radio*) should be solid PVC, not PVC tubing.

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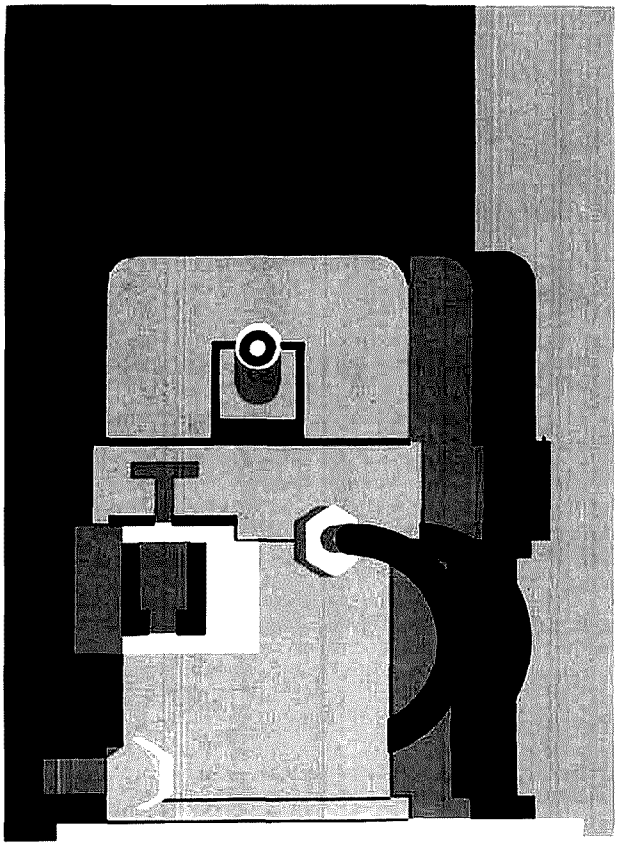
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converting surplus AN/UPX-6 cavities

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incorporating HAM RADIO HORIZONS

MARCH 1981

volume 14, number 3

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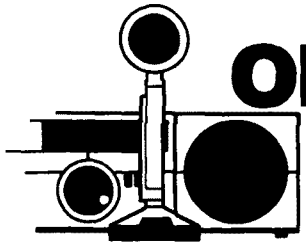
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Observation & Opinion

The January, 1981, issue of *ham radio*, which incorporated Ham Radio *Horizons*, resulted in a flood of mail. Responses were mixed, as expected. Readers who had never seen an issue of *ham radio* were surprised and pleased with the new magazine. Old-guard *ham radio* readers appreciated the new mix of articles. We also received complaints from *Horizons* readers, who expected all of their favorite features in the combined magazine.

A major change in a magazine format, such as was begun in the January, 1981, issue cannot be accomplished overnight. When the decision was made to discontinue Ham Radio *Horizons*, the January, 1981, issue of *ham radio* was almost "locked up" and ready to be sent to the printer. This state of affairs resulted in an intense scramble to include at least *some* of the Ham Radio *Horizons* articles. Production schedules are demanding and unforgiving in the magazine-publishing business, so it was impossible to include all the *Horizons* features in the January issue. Under the circumstances, we did the best we could.

We don't intend to abandon our faithful *Horizons* readers, nor do we intend to compromise the technical integrity of the magazine. If *Horizons* readers will bear with us for a few months, they will find more and more articles and features that made the *Horizons* magazine so popular. *Ham radio* has enjoyed a reputation for technical excellence for many years. We plan to continue this tradition.

Suggestions for article subjects were many and varied. These and the constructive criticism we received are gratefully appreciated. All were carefully considered, and future issues, now in the planning stage, will include as many different subjects as space will allow.

We received requests ranging from "more antenna theory" to "more on operating practices, station accessories, DX, and elementary theory." The demand for the continuation of "Ham Radio Techniques," "DXer's Diary," "Equipment Owners' Survey," and "Q and A" came through loud and clear. We got the message. You will see these features as well as some great stories that we've been keeping on the back burner. For the advanced Amateur, we have some interesting construction articles — in short, something for everyone. You asked for it; you'll get it.

caution

I'd like to direct your attention to a letter in this month's "Comments" column taking us to task for a potential safety hazard in the modular amplifier article that appeared in the January issue on page 12. It's a point very well taken, and I'd recommend that anyone planning to build this circuit take a close look at my reply to the letter.

That's it for now. See you next month.

Alf Wilson, W6NIF
Editor



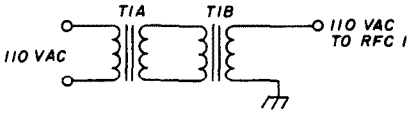
comments

safety hazard

Dear HR:

The otherwise excellent design of the modular linear amplifier by K8RA in the January, 1981, issue contains a potential safety hazard. In fig. 3, the amplifier control circuit, the two transformers are shown with one side of their primary windings connected to ground. If these primaries ever become disconnected from ground or were not properly soldered to the chassis, the entire chassis would be floating at 110 volts ac above ground. I sure wouldn't want to be touching the chassis if that ever happened.

Dave Karpiej, K1THP
Plainville, Connecticut



T1A, T1B 5V, 15A STANCOR P6433 OR EQUIV.

Neither would I. An easy and inexpensive solution is to use two small filament transformers connected back-to-back as shown in the drawing. This circuit thus isolates the two transformers in the amplifier control circuit and provides a much-needed safety feature. Editor.

Dear HR:

The circuit in the September, 1980, issue of *ham radio* referred to by Mr. Nelson is used in several thousand commercial radio telephone transceivers in New Zealand, and the notes I made on it were as a result of my bench work following modifications to put it on 144 MHz. The shorting of the crystal was only during a test setup. (Surely Mr. Nelson does not think I employ a little green man to short out the crystal each time I switch it on!) It is still flying too, after a year's operation.

True, there were other circuits in his article which probably would have been suitable, but this was the circuit built into the equipment so it had to be got going on its new frequency. It was satisfactory outside the Amateur band in its commercial use.

B.E. Graham Goodger, ZL2RP
Napier, New Zealand

Dear HR:

Author Mead, K4DE, did an excellent job of making a complex subject clear with his article, "How to Determine True North for Antenna Orientation." The only problem is that two years from now we will all have forgotten where that issue of *ham radio* is, along with its graph for the equation of time. There is another way to determine the time of meridian passage of the sun (local apparent noon), a way which does not require knowledge of the equation of time. It goes like this:

Look in your local newspaper and record the times of sunrise and sunset. Convert the sunset time to 24-hour time by adding 12 hours to it. Subtract the time of sunrise from the time of sunset. Add half the difference to the time of sunrise. You now have the time of meridian passage of the sun for the location for which the times of sunset and sunrise were computed. You will now have to determine what that location is (a call to the local U.S. Weather Service Office is probably your best bet) and make a correction for longitude difference between that location and your QTH, as explained in Mr. Mead's article.

Since the times of sunrise and sunset as published in newspapers are accurate only to the nearest minute, this method *may not* be quite as accurate as the method explained by author Mead. However, even though the sun's azimuth is changing more rapidly at meridian passage than at any other time of the day, 30 seconds' error in time will result in only a fraction of a degree of error in the resulting orientation. As an example, at latitude 35 degrees the azimuth change in 4 minutes at meridian passage is 1.7 degrees when the sun's declination is 0 degrees; it's 1.1 degrees when the sun's declination is 23 degrees south and 4.4 degrees when the sun's declination is 23 degrees north. Happy hunting to all you seekers after true north!

Thurman Smithey, N6QX
Chula Vista, California

Dear HR:

In response to W6DLQ, I would like to say the following: there are a variety of ways of determining true north. W6DLQ has correctly pointed out one of the better-known methods. My article was intended to be both educational and practical, and, in particular, to introduce some little-known concepts that can be used in Amateur Radio practice.

The use of Polaris is limited to those regions of the globe where the star is visible. This rules out the entire Southern Hemisphere, as I'm sure Jim realizes. Azimuth by meridian transit of the sun, on the other hand, does not have this limitation. Further, because Polaris is a circumpolar star (sidereal hour angle 329°, declination 89° N), accurate work requires a theodolite for taking azimuths at each elongation (not simply at dawn and dusk), afterwards splitting the difference. Alternatively, a time sight (at either upper or lower culmination) may be precomputed using the local hour angle of Aries and the Greenwich hour angle of Polaris. Tables for this method, along with latitude corrections, are included in the nautical almanac.

Donald C. Mead, K4DE
Greensboro, North Carolina

presstop

CABLE TV SYSTEMS, now expanding rapidly into many major urban areas, are posing a potential threat to Amateur Radio operations. Since they are supposed to be closed (non-radiating) systems, many utilize the VHF spectrum from 50 to above 225 MHz for their multi-channel content, providing subscribers with continuous tuning converters to permit them to tune in cable channels outside the standard 12-channel VHF TV band. This puts some cable-carried signals into the Amateur (as well as aircraft and public safety) bands, and when systems leak (an all-too-common occurrence due to corrosion, loose connectors, or cable damage) interference results. Cases of cable-system interference on Amateur repeater inputs have been documented.

Amateur Interference To Cable Reception is the other side of the coin. Cable subscribers who've paid to watch cable material being transmitted within an Amateur band aren't likely to be very sympathetic when poorly shielded converters pick up Amateur signals. The cable interference issue has come to a head in Richland, Washington, where Amateurs (and others) have thus far successfully opposed Teleprompter's efforts to open its transmissions across the VHF spectrum. Forty to fifty Amateurs were at the Richland City Council meeting January 19 to testify along with unhappy cable subscribers and an airline pilot about radiation and poor system performance. They convinced the council to vote against the expansion, and Teleprompter is required to improve its performance and report back March 3.

ARRL Has Been Watching the development of potential problems from cable TV, and would like to hear from any Amateur who has had difficulties with interference to or from cable TV systems. Because cable TV is a regulated utility, cable systems operators are required to take care of problems with their systems.

ARRL'S DXCC ETHICS RULE, Rule 12, has been strengthened considerably in a move directed primarily at DX stations who have allegedly been demanding payment before providing confirmation of a contact. The rules change comes as two additions to Rule 12, the first addition stating, "Credit for contacts with individuals who have displayed continued poor operating ethics may be disallowed by action of the ARRL Awards Committee," and the second including "confirmation procedures" as "operating ethics."

Impetus For The New Rule tightening had come from the ARRL's DX Advisory Committee, which in turn had been under ongoing pressure from many DXers over the practices of "buying" QSLs. The issue had come to a head following a well-known Israeli Amateur's insistence that only QSLs accompanied by a dollar bill would be acknowledged for his recent operations from various rare Pacific locations. The specifics of the change have been worked out and approved unanimously by the League's Awards Committee, and circulated to the DXAC.

The Expanded Rule 12 will actually become effective with its publication in QST, possibly as early as March. There are no plans to enforce it retroactively.

AN AMATEUR HAS BEEN PUT OFF THE AIR in yet another court action that could have far-reaching implications for the Amateur Radio community. In early December, K2AHL of Springfield, New Jersey, was ordered by Judge Kentz of the New Jersey Superior Court in Elizabeth to cease operating his station, as a result of a suit filed in 1977 by neighbors over TVI and stereo interference.

The Problem Had Surfaced a year earlier, when, without previous warning, he received a letter from the neighbor's lawyer stating that he'd be sued if he didn't stay off the air. Since the suit began, technical experts for both sides have agreed that a proper antenna plus filters would solve the TVI, and a properly designed stereo system would eliminate the problem in that area. Although K2AHL offered them a new stereo, they refused to make any changes. The judge apparently agreed they shouldn't have to, and even told K2AHL's lawyer he would have the FCC suspend K2AHL's license!

The Suit Has Cost K2AHL and his family $7,000 thus far, and an appeal is estimated at another $10,000. Nonetheless, he's willing to continue the fight if there are indications the Amateur community is behind him.

K6EOA WAS SENTENCED TO THREE YEARS felony probation and fined $500 for his threats against FCC engineers who were investigating jamming charges against him in 1979. The sentence was handed down in January by the Superior Court In and For the County of Los Angeles, and his probation will hinge on the condition that he does not use any of his Amateur equipment during the probation period and that he does not threaten, call, or harass either FCC officials or certain specified area Amateurs during his three years on probation.

He Will Also Be Required to obtain psychiatric treatment from a qualified M.D. at least once a week, and must obey all instructions from his probation officer and all other laws during his probation. Failure to comply with any of these conditions could put him into prison for the balance of the three years. The judge said the provision that he not use his Amateur equipment was an appropriate one in this case, since Munson had used his Amateur station in committing his crime.

converting surplus AN/UPX-6 cavities

A little scrounging, a little work, and you're on 1296 MHz with 40 watts output

In this day of microprocessor control, frequency synthesis and miniaturization, the thought of using surplus military equipment is almost an anachronism. Nevertheless, Amateur Radio can be served by tried and true methods — experiment! For example, if you've ever considered running more than a few watts output on 1296 MHz and have looked at the price of transistors capable of producing that power, you seek an alternative. One possibility is to obtain and convert the three-cavity assembly (described in this article) from the AN/UPX-6 transmitter. With 100 milliwatts of drive and a 600-volt power supply, you can obtain about 40 watts output on 1296 MHz.

According to *MIL-HDBK-162B*, "Radar Recognition Set AN/UPX-6 is part of the target identification equipment for a radar set in an IFF* system."

*IFF: Military jargon for "Identification of Friend or Foe." Editor.

So much for background, and on to the important data. The main component of the AN/UPX-6 is *Radio Receiver-Transmitter RT-264( )/UPX-6*†. The three-cavity assembly to be converted is part of that unit.

Each cavity houses a 2C39A, with the three cavities gang-tuned to cover a frequency range of 1080-1130 MHz. I've never seen the complete RT-264 ( )/UPX-6, but the cavity assemblies frequently show up at flea markets. (If any of this equipment is available from surplus dealers, I'm sure that it will be advertised shortly after this article is published.) At any rate, you can identify the complete receiver-transmitter from its nameplate or the cavity assembly alone from the pictorial presentation of fig. 1. There may be considerably more hardware attached to the cavities than shown, but only that part of the assembly shown in fig. 1 is used. Even if the interstage coaxial cables have been cut, don't despair — they can be restored with a minimum of effort provided that the end ferrules are still attached to the cavities.

†The use of open parentheses in military nomenclature indicates that the basic number or a letter-suffixed version applies; for example, RT-264/UPX-6, RT-264A/UPX-6, etc.

By Robert S. Stein, W6NBI, 1849 Middleton Avenue, Los Altos, California 94022

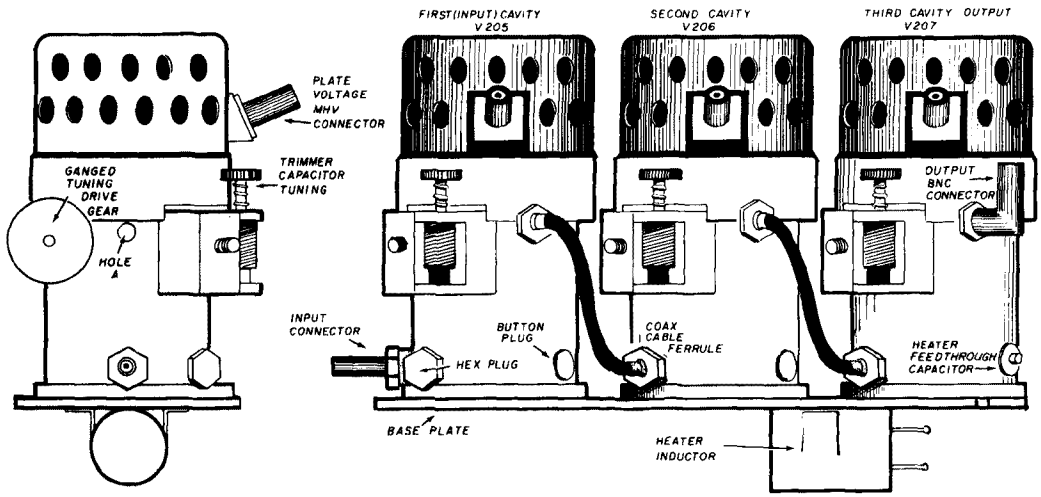


fig. 1. Unmodified AN/UPX-6 cavity assembly.

modifying the cavities

The mechanical modifications that must be made to raise the cavities' resonant frequency are relatively simple and require only standard hand tools. If you follow my instructions exactly as written, you should be able to complete the basic conversion in a couple of hours:

1. Remove all extraneous parts and material so that only the basic cavity assembly shown in **fig. 1** remains. Then refer to **fig. 1**, as necessary, when performing the following steps.

2. Remove the heater inductor and all wiring between the bases of the cavities and inside the base of the third cavity. Also remove the 10-ohm resistor and solder lug in the base of the third cavity.

3. Remove the perforated cover from each cavity. Remove the three screws, nuts, and washers that secure the spring-loaded tube retainer to the inside of each cover. Save the perforated covers; everything else may be discarded.

4. Carefully withdraw the tubes from the cavities (if you were lucky enough to find tubes in place) and clean out the accumulated dust, cobwebs, and spiders.

5. Remove the square access plate on the side of each cavity opposite the view shown in **fig. 1**. This permits access to the rotors of the ganged tuning capacitors. Save the access plates and the attaching hardware.

6. Loosen the setscrews that secure all the capacitor rotors, bushings, couplings, and spacers to the tuning shaft.

7. Remove the tuning shafts from the first and third cavities by pulling on the end of the shaft with pliers. Don't worry about using whatever force is necessary — the shaft and all the parts that will fall off are discarded.

8. Loosen the hex nut, at the bottom of the second cavity, which secures the coax cable between the first and second cavities. Unsolder the center of the cable from the input coupling capacitor in the base of the second cavity and pull the coax out of the cavity.

9. Remove the first cavity from the baseplate.

10. Perform **step 7** on the second cavity.

11. Loosen the hex nut at the input connection of the first cavity. Unsolder the wire from the center of the input coupling capacitor so that the input connection assembly can be removed and discarded.

12. Remove the hex plug from the base of the first cavity and save the plug.

13. Use a hacksaw to cut off the threaded portion of the input connection boss at the bottom of the first cavity. Then file down the remaining part of the boss so that it is flush with the flange at the base of the cavity.

14. Replace the hex plug that was removed in **step 12**.

15. Enlarge the input connection hole in the first cavity by drilling it out with a **3/8**-inch (**9.5**-mm) drill.

Then ream or file the hole so that it will accept the threaded end of a UG-1094/U BNC connector. *Be careful not to damage the input coupling capacitor inside the base of the cavity*! Clean out all filings, especially on the faces of the input coupling capacitor.

16. Insert the UG-1094/U connector into the input connection hole to determine how much of its center contact must be trimmed so that it *just touches* the center contact of the input coupling capacitor. Cut and/or file the connector contact accordingly. *NNOTE:* Be sure to use a UG-1094/U, not a UG-1094A/U; the latter is too long.

17. Install the UG-1094/U connector in the input connection hole, and solder its center contact to the center of the input coupling capacitor.

18. On the *input* sides of the first and second cavities only, locate a point directly below hole **A** which is 1/2 inch (12.7 mm) below the bottom of the top flange, or 7/32 inch (5.6 mm) below the bottom of hole **A**. At each of these points, drill and tap a 10-32 (M5) hole.

19. On the first cavity only, locate a point directly above the button-type heater feedthrough capacitor (not visible in **fig. 1**), which is 27/32 inch (21.4 mm) below the bottom of the top flange. At this point, drill and tap another 10-32 (M5) hole.

20. Use an ohmmeter to determine that there are *no shorts to ground* a) from the center contacts of the input coupling capacitors, b) from the heater feedthrough capacitors, and c) from the plate-voltage connectors of all three cavities.

21. In each of the three tapped holes, insert a 10-32 x 5/8 inch (M5 x 16 mm) brass screw so that it butts against the grid line inside the cavity. The screw must seat firmly to ensure a good rf short circuit between the grid line and the cavity wall. Be careful *not to overtighten* the screw and strip the threads in the thin cavity wall.

22. Reinstall the first cavity onto the baseplate, then resolder the center conductor of the coax to the input coupling capacitor in the base of the second cavity. Tighten the hex nut.

23. Fig. 2 is a view looking into the access hole from which the cover was removed in **step** 5. Use a heavy soldering iron to tin the tips of the crescent-shaped bosses on the grid line inside each cavity and to tin the top and bottom horizontal surfaces of the access hole flange. Solder a short length of 3/8-inch (1-cm) wide copper strap between the crescent tips and the flange of the access hole as shown.

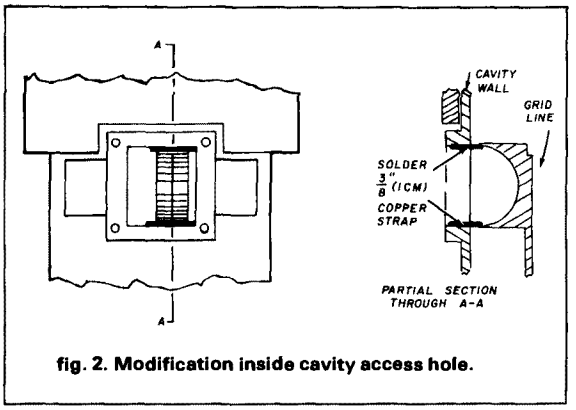


fig. 2. Modification inside cavity access hole.

24. Replace the access hole cover plate on each cavity.

25. If the inter-cavity coax cables are intact on your cavity assembly, you have completed the mechanical changes and can proceed directly to **step 46**. However, if you have to replace one or both of the cables, continue with **step 26**.

26. If not already done, cut the cable close to the end ferrules.

27. Remove and save the hex nut and washer used at the end of each cable.

28. At the ends of the old cable, unsolder the center conductor from the output coupling loop (physically, a grounded plate parallel to the cavity wall) and from the input coupling capacitor. Remove the remainder of the coax. Save the ends of the coax to recover the end ferrules.

29. Clean out the old solder from the holes in the output coupling loop and the center of the input coupling capacitor.

30. Extract the center conductor from the ferrules on the ends of the old coax, and trim off as much of the old coax as possible. Then, using a number 17 drill, enlarge the hole in each ferrule to 0.173 inch (4.4 mm).

31. Clean out the solder holes in the ferrules. Make sure that the inside bore of the ferrule is smooth.

32. Trim a length of RG-142 B/U coaxial cable to 6-1/2 inches (16.5 cm). (The instructions which follow, covering the assembly of the ferrule to the coax, apply to one end.)

33. Strip back the outer jacket 1-1/2 inches (3.8 cm). Take care not to nick the braid.

34. Push the braid back slightly, being careful not to unravel the braid. Cut 1/8 inch (3.2 mm) of dielectric and center conductor off the end.

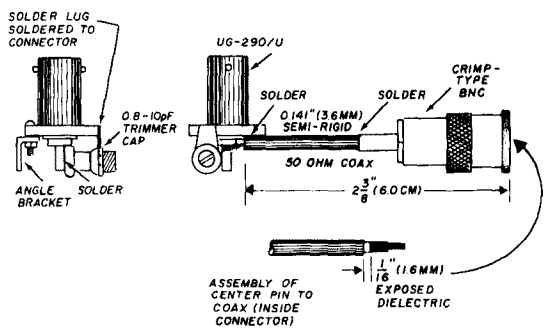


fig. 3. Stub matching network used at input to first cavity. The 0.8-10 pF trimmer capacitor is a Johanson 5200, JFD MVM010M or equivalent. The crimp-type BNC connector is similar to the UG-88/U series except that it's normally used for crimp assembly of RG-58/U cable.

35. Reform the braid so that it tapers over the cut end, which will make it easier to assemble the ferrule to the cable.

36. Slide the modified ferrule over the end of the coax so that the corrugated *end butts* against *the* jacket.

37. Solder the braid to the ferrule through the solder holes in the ferrule. Be sure that the solder is sweated around the entire periphery of the cable.

38. Trim the braid that extends through so that it's flush with the end of the ferrule.

39. Trim the dielectric so that only 1/8-inch (3.2 mm) extends beyond the end of the ferrule. Do not cut off the center conductor.

40. Place one washer and hex nut, removed in step **27**, over the end of the coax so that the washer is against the ferrule and the threaded end of the hex nut is against the washer.

41. Place a second washer and hex nut onto the cable so that they are a mirror image of the set already in place.

42. Repeat steps **33** through **39** for the other end.

43. Insert one end of the cable into the top of the applicable cavity so that the bared center conductor passes through the hole in the output coupling loop. Determine how much of the center conductor must be cut off so that it will extend through the coupling loop about 1/32 inch (1 mm). Remove the cable and cut off the excess center conductor.

44. Reinsert the cable center conductor into the hole in the plate coupling loop and tighten the hex nut. Solder the center conductor to the coupling loop.

45. Insert the other end of the cable into the bottom of the succeeding cavity so that the center conductor passes through the hole in the center of the input coupling capacitor. Tighten the hex nut, solder the center conductor to the capacitor, and trim the excess center conductor.

46. Install a 2C39A tube in each cavity. Replace the perforated covers removed in step **3**. Do not substitute a 7289 or 3CX100A5 tube for the 2C39A. Although they are similar, neither will work properly in the modified cavities.

input matching

The VSWR at the input of the first cavity will be between 40 and 50 (that's right!) after it's been modified. Therefore, to obtain a reasonable power transfer, especially from a solid-state driver, some form of input matching must be provided. A simple matching network, which should bring the VSWR down to better than 2:1, is shown in fig. 3. The configuration is that of a stub matching network in which a discrete variable capacitor is used instead of a shunt capacitive stub, thereby permitting the network to be tuned to compensate for variations in the input impedance of the cavity.

The matching network should be constructed *exactly* as shown in fig. 3. Use a crimp-type BNC connector, similar to a conventional UG-88/U, designed for RG-58/U cable; the crimping sleeve is not used. Before cutting the semi-rigid coax to length, solder the connector pin to one end, trimmed as shown. Insert the semi-rigid cable into the connector body to position the pin properly. Solder the coax to the connector cap.

Trim the outer conductor to the 2-3/8-inch (6.0-cm) length shown, allowing about 1/2 inch (13 mm) of additional bare center conductor for connection to the center contact of the UG-290/U receptacle. Solder the outer conductor of the coax to the body of the receptacle to minimize the length of the unshielded center conductor to be soldered to the receptacle contact. Trim the excess center conductor after soldering it to the connector.

Solder the trimmer capacitor on the UG-290/U as shown in fig. 3. The small angle bracket is not required electrically; it is used only to secure the connector to the chassis or mounting surface upon which the cavity assembly will ultimately be mounted.

input VSWR

The input VSWR can be checked at this point, before applying any power to the cavities, if a signal generator, slotted line, and SWR indicator are avail-

able. Otherwise, an alternative check can be performed under operating conditions.

Using the slotted-line technique, you should be able to reduce the input VSWR to 2:1 or less by adjusting the trimmer capacitor on the matching stub. If the measured minimum VSWR is greater than 2:1, add a 5.5-18 pF trimmer across the 2C39A input circuit inside the base of the first cavity. One side of the trimmer should be soldered to the solder lug in the center of the cathode structure (one of the heater rf chokes is connected to this lug). Add a solder lug and nut to one of the studs that support the ends of the cathode structure. Solder the other side of the trimmer to this lug. Adjustment of this capacitor, in conjunction with the matching-stub trimmer, will then result in better than a 2:1 VSWR.

power supplies

I'll not attempt to detail the heater and plate power supplies, since the choice of plate voltage and bias voltage usually depends on what each person has available and his preference as to control. Instead, I'll present some ideas, along with tube limitations, which may be helpful. I assume that all operation will be CW or SSB.

First let's consider the plate-voltage supply, since bias and control may depend on this voltage. My preference is to use as high a voltage as possible, but not over 1000 volts, on the output stage, and to use about 350 volts on the first two stages. This provides for maximum power output, yet allows the first two tubes to operate with zero bias so that only two heater supplies are required. (More about this under the discussion of heater requirements.)

If the plate voltage is limited to 350 volts, a 2C39A will draw 50 to 60 milliamperes static plate current when zero biased. The plate dissipation limits for the tube are 12 watts with convection cooling and 100 watts with forced-air cooling. Therefore, a small blower or fan is recommended, especially if 500 volts or more are used on the last stage. Placing the blower at the end of the cavity assembly, facing the third cavity, will afford maximum cooling for that stage while also dissipating heat from the first two cavities.

Plate voltage is applied to each cavity through the MHV connectors shown in fig. 1. The required mating MHV connector is an Amphenol 29100 for RG-58/U cable, or an Amphenol 28000 for RG-59/U. The latter is recommended, since the RG-59/U has a higher breakdown voltage rating than RG-58/U. If you can't obtain the mating MHV connectors, or if the receptacles on the cavities are damaged, the cavity receptacles can be replaced with more conventional UG-290/U BNC connectors. In that case, use UG-260/U cable connectors so that RG-59/U can be used.

Biasing. Because the 2C39As are used as grounded-grid amplifiers, with the grids at dc ground, a positive dc bias must be applied to the common heater-cathode connection when bias is required. This means that each tube must have its own heater supply unless the tubes are zero biased or operated at sufficiently low plate voltages so that a common bias source will keep the plate currents of two or three tubes reasonably close to a bogey value.

As the cavities exist (after the preceding modifications have been made), the heater-cathode leads of the first and second stages are returned to ground through rf chokes, while the rf choke in the other heater lead in each cavity is brought to a feedthrough capacitor in the cavity wall. In the output cavity, both heater rf chokes connect to feedthrough capacitors.

If the plate voltage for the first two stages is limited to about 350 volts, the heater and bias circuits shown in fig. **4A** may be used. The values of R1 and R2 must be such that the heater voltage, measured at the heater ends of the rf chokes, is 5.5 volts. CR_k provides cathode bias and is made of several silicon rectifiers (1N4001 or similar), so that the quiescent

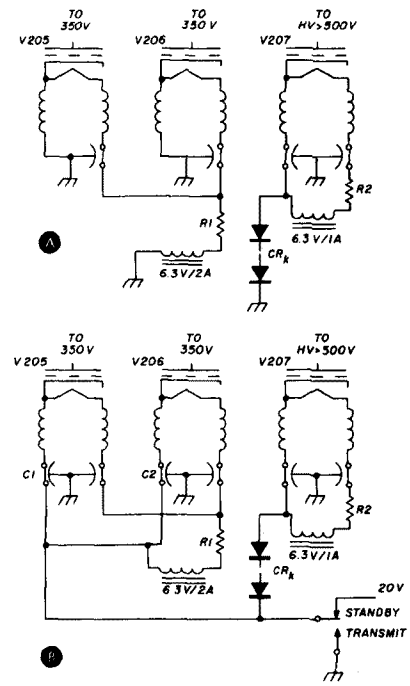


fig. 4. Suggested heater and bias circuits for the modified cavities. (Refer to text for a discussion of C1, C2, R1, R2, and CR_k.) Illustration *A* shows heater and bias circuits for plate voltages indicated. Heater and bias circuits for the same plate voltages in *A* are shown in *B*, with cutoff bias during standby.

plate current of V207 is between 40 and 60 milliamperes; the number of diodes in series will depend on the plate voltage and the tube characteristics. With a plate supply of 600-700 volts, four diodes should provide the proper bias.

If higher plate voltages are used on the first two stages, or if either is not to be operated under zero-bias conditions, a separate heater transformer will be needed for each tube. The tubes may then be individually biased, in the manner shown for V207.

Recommended circuit. One of my phobias is to have transmitting tubes draw plate current during standby. Consequently, I use the biasing circuit shown in fig. **4B**. Cutoff bias of about +20 volts is applied to the cathodes of all three tubes through the normally closed contacts of a relay. When the relay is energized for transmit, V205 and V206 cathodes and the low end of CR_k are grounded, allowing plate current to flow. This requires lifting the heater-cathode returns of V205 and V206 from ground as follows:

Cut the ground ends of the rf chokes in the bases of the first and second cavities. Remove the button plug at the bottom of each cavity (see fig. 1) and replace it with a button-type feedthrough capacitor, designated C1 and C2 in fig. **4B** (similar to those used for the ungrounded heater connections). The capacitance value isn't critical; anything between 100 and 1500 pF will do. Connect the ungrounded end of the rf choke to the new feedthrough capacitor.

operation

After the power supply smoke test has been made and the tube plate currents checked, connect the input matching network to the input connector on the first cavity, then connect your exciter to the matching network. If the matching network capacitor has not previously been adjusted for minimum VSWR, set it near minimum capacitance.

The trimmer capacitors on the cavities (see fig. 1) tune the cavities to resonance, the old ganged tuning capacitors having been removed. With rf drive applied, the cavity trimmers are tuned for maximum output, as is the matching network capacitor. If the additional trimmer capacitor has been added to the input of the first stage to minimize the input VSWR, it may also be adjusted for maximum output. Its effect will be slight, however, if it has been set for best VSWR.

wrap-up

That's all there is to getting the modified cavities on the air. The output-stage plate current will be about 200 milliamperes at full output. However, don't allow the tube to draw that much current for any extended length of time. Maximum plate current for a 2C39A is 125 milliamperes. Plate efficiency will be about 30 per cent, which is consistent with the tube specifications.

A drive level of 100 milliwatts should be more than enough to obtain full output at any final-stage plate voltage up to 1000 volts.

If you don't have an rf power meter, you can calculate the output power from the dc input power, assuming a plate efficiency of 30 per cent. (We can ignore the feedthrough power from the second stage, since we're assuming the efficiency to arrive at only a rough estimate of the output.)

If you don't obtain output power corresponding to about 26 dB of power gain in the cavity assembly, one or more of the tubes may be weak. However, if the input VSWR hasn't been checked, it's possible that the mismatch loss between exciter and first stage is the culprit. Add a trimmer capacitor across the first-stage input, as described earlier, then adjust this capacitor, along with the trimmer on the input matching network, for maximum output. This should solve the problem.

postscripts

At drive levels under 1 milliwatt, the over-all gain of the three cavities is 28-34 dB, depending on plate voltages. However, at the higher drive levels needed to produce power outputs of more than 20 watts, full gain can't be realized. It's likely that the over-all gain might be increased at these higher outputs, thereby reducing the drive levels required, by replacing the interstage connecting cables with matching networks.

Although I've not tried this, preferring to stay with the simpler brute-force approach, my rationale is based on the VSWR that the first stage presents after modification. There's no reason not to believe that severe mismatches may occur between first and second and second and third stages.

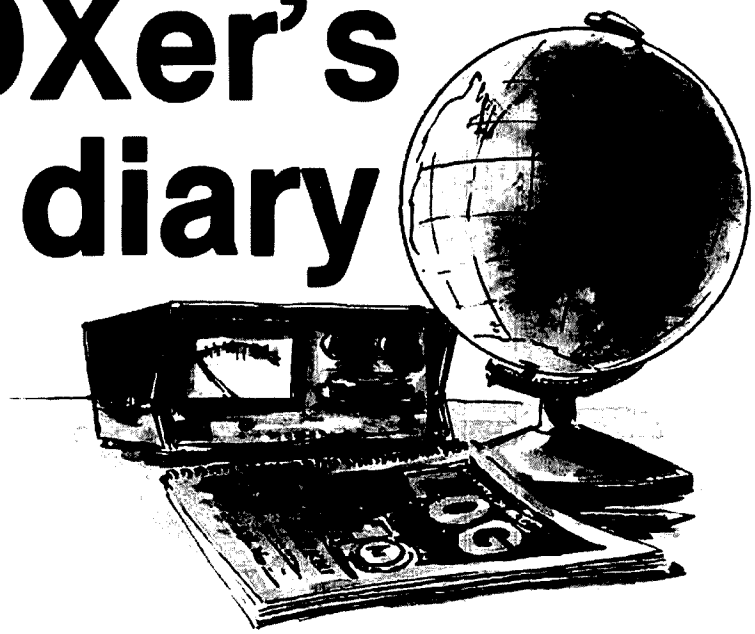
It's interesting to conjecture on the results that might be obtained by matching. If we assume a gain of 11 dB per stage and an output of 40 watts, only 20 milliwatts of drive should be required.

It should also be apparent that one, two, or three cavities can be used, depending on available drive power. I've run tests using only two cavities and obtained approximately 16 watts output with a drive level of 100 milliwatts — a power gain of 22 dB — indicating that the limiting occurs in the final stage when three cavities are used.

I'd be interested in hearing from anyone who attempts to improve the interstage matching. I'll also answer all inquiries accompanied by a self-addressed, stamped envelope.

ham radio

DXer's diary



Author Locher was a popular contributor to *Ham Radio Horizons*. Because many *Horizons* readers are now receiving *ham radio*, we are presenting this episode of W9KNI's ongoing battle of the big guns in the DX world. Want to see more articles by W9KNI? Let us know how you like it. **Editor.**

By Bob Locher, W9KNI

It's Saturday at 1300Z; 7 AM in Chicago, a late winter's morning. Considering the hour, I feel pretty good. An early retirement last night and a good sleep, and now I'm ready for DX.

The warm glow of the dial lamps, the smell of the fresh coffee, the warmth of my heavy bathrobe pulled tightly around me, the headphones nestled over my ears — I'm at peace with the world and ready to go.

There are a couple of stations I'd like to tie into this morning. That A51RT is high on my list; three times now I've heard him, with nothing to show for it. Not that he's being pursued all that widely; he's been listed in the DX bulletins only once, and that was for an evening path. Every time I've heard him was on a morning path. Of course, as soon as I QSO him, I'll report it to the DX bulletins, but with the luck I've been having with that one, the last thing I need is more competition.

But the A51 isn't the only DX station I'm after. The bands were full of talk and reports last night that ace DXpeditioneer KP2A had managed to pull off both a ticket and a pass for Cocos-Keeling, VK9Y, and would be operational any moment now.

Cocos-Keeling has always been a tough one; not an easy shot for propagation to start with, and a location remote from anywhere. Add to that Australia's military making it a high-security area a couple of years ago, and you have the makings of a rare country, a very rare country.

Every one knows the difference between a rare country and a very rare country: A rare country is one that you have and your buddy doesn't. A very rare country is one that your buddy has and you don't. I don't have Cocos Keeling.

Let's see how the band sounds. Hmmm. A number of signals; that's certainly a good sign. Let's see where they are from. Haul the antenna around — let's start straight west. Watching for both the A51 and the Cocos-Keeling station poses certain difficulties — beam headings. The A51 has been coming through on long path, almost dead south, over the Antarctic. The Cocos-Keeling bearing, on the other hand, is more northwest, over Japan. The signal from the A51 is weak enough that I can copy it only when the antenna's on him; no way can I copy him on the side or back of my antenna. Perhaps I should leave my antenna on the long path for the A51?

On the other hand, I can develop a very good case for leaving the antenna on that VK9Y bearing. With any DXpedition, or for that matter, any new country, it is always desirable and advantageous to grab a QSO ASAP — As Soon As Possible!

I'll never forget my lesson of Serrana Bank some years ago. A DXpedition came on one evening from there, and seemingly half the world was in one pileup. I decided to wait a day, so that getting a QSO would be easier. Guess what? An approaching hurricane forced them off the island at dawn, and they never went back. I had to wait years for a Serrana Bank QSO from another DXpedition.

On top of that lesson, the path to Cocos-Keeling is a long one, and this time of year propagation can be a bit tenuous. We certainly will get openings, but the peak part of any opening won't be over half an hour, and perhaps less. Catching the peak is vital on a DXpedition like Cocos-Keeling; the competition can be so fierce from all over the world that in a really huge pileup you need all the help you can get from propagation.

Even so, the easiest way is to catch him calling CQ, and nail him before the ravening hordes get onto him.

KP2A is fairly predictable. He's a superb operator, cool under fire, which, God knows, he's going to need to be, and he controls pileups very well from DXpedition QTHs. From past observation, I know that he likes to work 5 to 10 kHz up from his own frequency. Also, he has a knack of getting a good signal out; he seems to know how to set up

decent temporary antennas, I guess.

Okay, enough wool gathering. Let's see here, it's 1314Z. Okay, I haven't yet heard the A51 before 1340Z, so I could start watching for him at 1330Z. That would give me fifteen more minutes to hunt for the VK9Y. Then, I think, if there's no action, I'll swing the antenna every five minutes to watch for both the A51 and the VK9Y. If I come across either of them, I'll devote all my attention to that one. So, let's go! I move the antenna into the northwest, the path for Cocos-Keeling, and start hunting.

KP2A seems to like to transmit around 020. I'll center my tuning around there. Let's see what we have here. Lots of W signals, some pretty loud. Phooey. Guess the skip is a bit short today. It figures. If that VK9 shows, sure do hope that the traffic cops don't show up. There's a VK4.

Yes, VK4RF. Good signals. That's not the exact path for Cocos-Keeling, but there's hope.

There go four or five fellows chasing someone. Maybe it's my boy? No — there — one of the Ws gives the call of the fellow he's calling. It's P29ET; Papua/New Guinea. That's a nice catch, but I don't need it. But let's wait a bit and see what kind of signal the P29 has. There he is. Fine, a good S-7 and no flutter. Ohhkayy — if Cocos is going to show up soon, I should be in tall clover, propagation-wise. That P29 isn't as far down the path as the VK9Y is, but it's pretty much the same path, and that's the tougher part of it. It's a pretty safe bet that we'll have at least adequate propagation to Cocos-Keeling.

Let's flip on 2 meters to see if anyone has any late information or hot tips.

"Hellooooo out there. W9KNI here. Any late information on the VK9Y?"

"Yeah. W9KNI from K9QVB. Hello, Bob. I was just going to call you. He showed up a few minutes ago on 20 sideband. He's on fourteen-one-nine-two, listening up. Said he's going to CW on oh-twenty at fourteen hundred zulu. He's not real strong. Over."

"Okay, great, John, and thanks for the hot stuff. Who's he working?"

"He's mostly on W4s. He's getting a few threes, and W9ZRX with that super stacked system got him too. But I think the W4s have a long-path opening to him, and they're working it to death. The guy's a pretty good op, for sure."

"Roger, he's that. What path are you copying him on?"

"Definitely short path. I can't hear a whisper on long path. But he's pretty weak. I think he's starting to get stronger, though."

"Okay, fine, John. Appreciate the info. You need him too, I think?"



"Yeah, sure do, Bob. I thought I worked that VK9YK a couple of years ago, but I got my card back with a 'Not In Log,' so I guess I didn't make it. Yeah, I need this *one*. But I'm not even calling him right now; he's four and four here, and the W4s are all giving him five-eights and five-nines. Hope we get a better shot on CW."

"Okay, I'm going to run and get a cup of coffee, John. I'll be back in five minutes or less. Good hunting. K9QVB from W9KNI."

"Okay, Bob. I'll squawk if anything changes. W9KNI from K9QVB."

I run up the stairs and turn on the water for my coffee. The juices are starting to flow — a shot at a new one — with a good operator, too. And, on a Saturday. Incredible! It's been a bit dry of late for new ones in the log. Oh, I heard a few — the A6X, the A51, the VK9 on Norfolk. But I'm not chasing SWL awards; I'm looking for QSLs that say, "RST 599" on them, or whatever report. And lately, I'm not getting any of them into the log book. Maybe today's my day.

In minutes I'm back at the rig. Let's see here... I adjust the headset a bit to seat it comfortably, and move the gleaming Bencher paddle to where it is most comfortably placed. KP2A is a pretty sharp operator — I ease the keyer speed up a bit, and dry fire a few letters to get my timing down. My fingers respond almost instantly to the higher speed — I feel like a sports car driver just before the start of the race: headphones are my driving helmet, my paddle the gear shift, the receiver dial my steering wheel. I fire up the linear, get it all tuned on an empty frequency just above 14030, and I'm set.

"W9KNI from K9QVB. Okay, Bob, he just said that he's going to take a two-minute break, and then be on fourteen-oh-twenty. You ready?"

"Yeah. K9QVB from W9KNI. Great, John, thanks. Yeah, I'm as ready as I'll ever be. Hope we get him."

I reach for my cup of coffee — and leave it — I've got butterflies enough.



I am the knight in armor at the end of the lists, awaiting the trumpet call. I am the Spitfire pilot revving up the engine at the end of the runway, just before takeoff to certain battle. I listen to all the carriers tuning up as I set my receiver on 14,025 — they are all out there, waiting. It's me against the wolfpack.

"Hey Bob?"

"Yeah, John, go ahead."

"Hey, don't forget, it's only a hobby."

That breaks the tension, and my wild flights of fancy. I laugh.

"Naw, you got it all wrong, John. It's not a matter of life and death. It's more important than that."

"Haw, Haw. Okay, he should be on any second now. W9KNI from K9QVB."

"Roger, K9QVB from W9KNI. Hey John, what call is he signing?"

"Oh. Yeah, he's VK9YR — Yankee Radio."

"Thanks."

Ohhkayy! Let's go. Lemme see here. KP2A likes to set up a little lower than the usual 025; he'll probably transmit on 14,021 or 022, and listen up around 030.

Huh, what's that? There, on 020, maybe 559, 569, "5NN W4QM, K."

4QM — yeah, he's one of the South Florida aces. I give the receiver a quick turn up a few kHz. "5NN TU VK9YR DE W4QM E E." Yup, there he is, as I pick up the VK9 again.

"R 73 QRZ NA NA UP5 DE VK9YR K."

I blindly set my VFO on 025, and stroke the paddle.

"DE W9KNI K."

"4QQN 5NN K." Hmm. Another four. I check my transmit frequency. There's QQN. Okay, I'm half a kHz low. Move it up. There, a hair above QQN. The VK9 clears. Call. Keep it short, this fellow's good. Okay, N4OW got him. He's in Florida too. He clears. Call now. Huh? He's back to N4WW this time. Florida again. There's K9QVB calling too. Okay, I don't need to alert him on 2. The VK9 clears; call now! There. He's back to W4FLA — and Florida again. Let's cool it for a moment and consider all this.

I've been calling at about the right frequency every time, almost, but it sure looks like the W4s are milking the long path for all it's worth. But it's getting later in the morning, and that path can't hold up very much longer. Also, our peak time should be coming fairly soon; with any luck we Midwesterners should get a good shot within the next half hour. The fellows that are going to get stung are the boys on the upper East Coast. Their short path peak is being overridden by the Florida long path shot, and by the time that path is gone, so will the East Coast short path. Oh well, they leave us for dead on the short path into the "middle east," so I guess it will all come out in the wash.

But, while the fours still have it in such convincing fashion, I'd be smart to quit transmitting and study his techniques. That way, when he does start working W9s, I'll be ready for him. Okay, he's back to W4MLP. Find MLP. There he is; note the frequency — yes, 026.3, plus or minus. He clears. Now — KB4CH has him. Okay, 026.6. He clears. Listen to that pileup! Back to the VK9. Yes, he's got KT4X. There's the KT4, 026.9. All right! The VK9 is working up through the pile. Fast, too. One call seems to get him. None of your 1X3s for this boy. Great!

4BW — 027.1. W9QN — huh? No, he's in Florida too, 027.3. Thought for a moment we nines had broken the stranglehold. Oh well, our turn will come.

Hey, this boy IS good. I notice with admiration how he's picking up only the stations that give him an X1 call — in other words only sign their own call, and only once. That's the mark of a very good DXpedition operator. There are two ways to do that, and both are tough. One is copy several signals simultaneously and choose the one that meets the X1 rule. The other is to copy the call a QSO ahead and pick it up one QSO later. But either is tough to do. However, a skilled operator can get a QSO rate that is 50 per cent higher than he can without that selection. And at the rate the VK9's going he might be good for a 150-QSO-per-hour rate. That's really great for us: it

means our chance of a QSO in a brief opening is greatly enhanced.

Okay, KG4TH — where's he? Oh, yes, 027.6. Now it's N4BKU; yup, 028.0. KB4AJ 028.3. Okay, he's moving up 300 to 350 hertz every QSO, apparently always moving after each. Now, is he going to keep moving up, or will he stop and start tuning down, or will he suddenly move down and start tuning up?

W4TO — where's he? He ought to be about 028.6. But no. Back to the VK9's frequency. He clears. Maybe he's moved. There, he's got N4AR. Wait a minute! That isn't Florida, that's Bill in Kentucky. Maybe the path has shifted. Quick, go ahead and look for him. He's probably a back-scatter signal.

Yes! There he is, 024.2. All right! Let's try 024.5. Call; just one. The paddle dances under my fingers, "DE W9KNI."

"WB8EUN 5NN K." Darn! Okay, there's EUN, right on the same frequency I was. He clears. "DE W9KNI K."

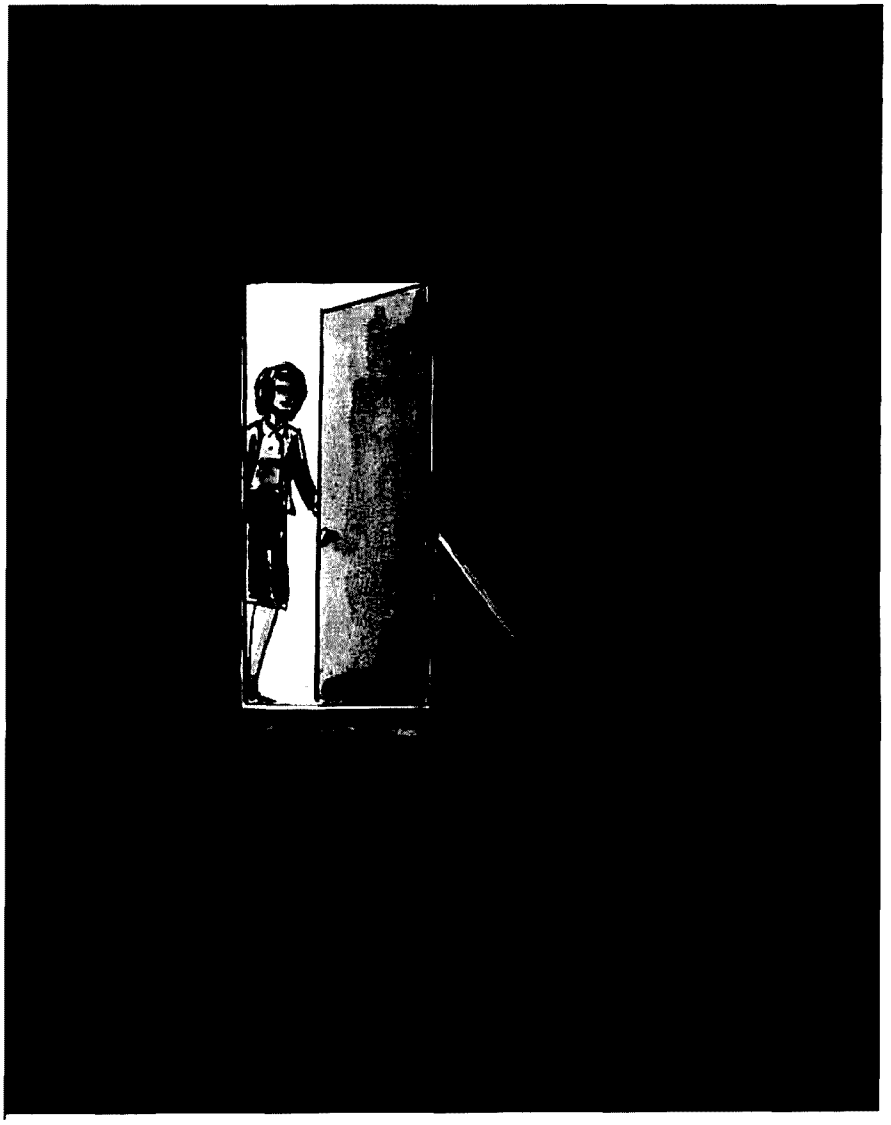
"W9BW DE VK9YR 5NN K." Where's BW? There, above me about 200 hertz. Up 300 for me above BW.

"DE W9KNI K."

"K9QVB 5NN K." Good for QVB. There he is, just about zero with me. Okay, up 200 again.

"DE W9KNI K."

"WØSR 5NN K." Yup, the fours have lost the path. Hope I get one. There's ØSR on backscatter. He's about 200 above me. Okay, my steps up seem to be a little too small now; he seems to be jumping about 400 at a time. Move the VFO.



"DE W9KNI K."

"K9RF 5NN DE VK9YR K." Well, the nines seem to have a lock on him. It would be nice if I could be one of them. Up another 400 hertz.

"DE W9KNI K."

"K9DX 5NN K." Where's DX? He's nowhere near my frequency. Quick, look down. Yes! 023 and a hair. The VK9 shifted back down. Quick, about 300 above DX. Call!

"DE W9KNI K."

"W9KNI 5NN DE VK9YR."

"VK9YR 5NN TNX DE W9KNI."

"R TU E E."

Wow! Just like that. The actual QSO took under ten seconds. But he's all mine. I'm in the log. I notice that I'm breathing fast. Ah, it feels good to inscribe the rest of the details into the log.

I turn 2 meters back up; I must have turned it down earlier in the fray, but I don't remember.

"Twenty-eight. Twenty-eight."

"DWQ's got him. Way to go Ed!"

"Twenty-eight point five, eight point five." I recognize K9DX's voice.

"It's WØVX." There's K9RF giving the call signs.

"Twenty nine oh. Watch it, he's going to move back down."

"K5LM."

"He moved. Oh twenty three two. Call up a little."

"K9AJ, good work, Mike."

"Twenty three five."

Ah, the 2-meter net is having one of its finest hours spotting frequencies for the rest of the club. It was a free-for-all at first, but as soon as a few members made it through, they started coaching the rest. But I'm glad I figured it by myself. Not that I'm against help, but it is nice the other way.

"W9OA — way to go, George."

The basement lights blink; my signal to lift up my headset a moment.

"Bob, breakfast's ready." A wave of sausage aroma follows my wife's voice. They don't need me here on 2 meters — and I'm hungry!

ham radio

Collins Owners' Reports:

KWM-2
KWM-2A

A survey of owners' opinions on these two popular transceivers

The April, 1980, issues of *ham radio* and *Ham Radio Horizons* carried questionnaires directed at the owners of Collins equipment: 32S-line transmitters, 75S-line receivers, and the KWM-2 and KWM-2A transceiver. In this issue, we will present our readers' opinions on the KWM-2/2A transceiver. Next month, we'll give you a rundown on what our readers had to say about their S-line gear.

the good features

By far and away the single most commonly mentioned feature of the Collins KWM-2/2A transceiver is its great reliability. More than any other characteristic, reliability seems to be the hallmark of these radios. In a way, that's not too surprising: many of these rigs (27,000 have been built since 1958) have seen continual use for more than 20 years. Virtually every owner of a KWM-2 or KWM-2A included praise for its reliability among his comments.

Running just behind reliability on the list of best features were stability and audio quality. Take a look at the table of Best Features and you'll get a feel for just how many owners of these Collins radios were happy about the superior stability and audio of their transceivers. Also well represented among the Best Features were wide frequency coverage (making it possible to operate the new frequencies opened to Amateurs as a result of the 1979 WARC), ease of operation, solid construction, and dial accuracy. Below are some representative comments by our respondents to the question, What is the rig's best feature?

"The KWM-2A has excellent stability, accurate readout, and good audio quality both transmit and receive. It has *large* knobs that are easy to use, and

By Martin Hanft, WB1CHQ, Production Editor, *ham radio* magazine

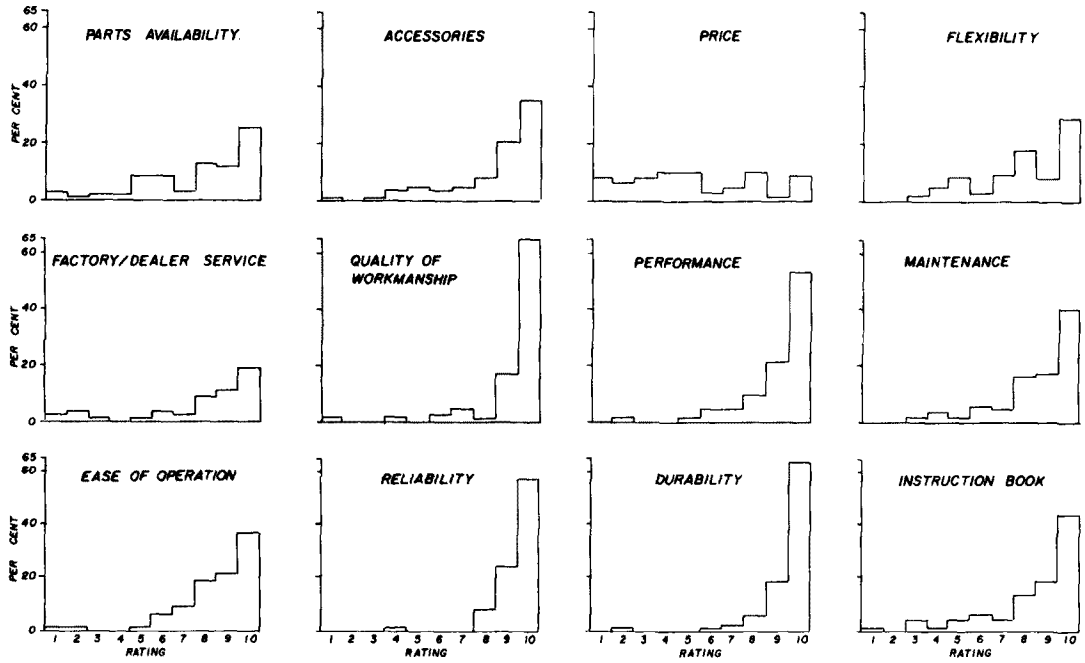


fig. 1. How the KWM-2/2A was rated, from 1 (poor) to 10 (perfect).

it's built like a battleship. Long life expectancy and very neat looking design of front panel." — WØRJ

"Wide frequency coverage, good reliability, easy to operate, good human engineering, good frequency readout and stability, no TVI problems." — W3PE

table 1. Best features

	percent
reliability	37
stability	25
superior audio quality	18
wide frequency coverage	14
dial accuracy	13
solid construction	13
easy to operate	11
good frequency readout	11
good selectivity	6
front panel design	4
easy to service	4
frequency accuracy	3
service manual	3
resale value	3
no TVI	1
VFO	1

"The VFO. It is low-drift and calibrated accurately enough to be precisely resettable." — KH6S

"Absolutely superb audio quality. Addition of a speech processor increases average audio, but disturbs pureness of the audio signal as originally designed by Collins. Collins Field Service Engineering department very helpful, considerate, and prompt." — WD4CWF

"Dial accuracy and dependability. Stability. Every bit as accurate as the digital (readout), and certainly the dial is easier to turn with the thumb hole." — WA6UZL

"Reliability, ease of operation, and solid construction." — VE3RO

"High resale value. The radio has good audio and is easy to maintain. There's a very good instruction and service book that comes with the equipment." — K5NG

"The design of the receiver circuits. The permeability tuned rf circuits plus the careful design of the whole receive chain are, to me, the hallmarks of this rig. There is a combination of sensitivity and rejection of unwanted signals that is as good as anything manufactured today. There is still nothing that will outperform this KWM-2." — K5RSG

"Superb audio quality combined with sharp selec-

tivity inherent in the mechanical filter. Truly accurate frequency readout without having to resort to digital displays. Beautiful appearance."

"It's a well-engineered tube-type rig, which leads to unusually good frequency stability, matchless audio, tolerance for SWR, and relatively easy owner servicing." — WØRHW

"Faults with the Collins are few and far between." — WAØPSG

"Dependability." — K9LKA

"Durability: This rig is over 20 years old and has needed only minor servicing." — WD5CKA

"This rig with its external VFO, crystal pack, and speech processor is exactly what I need for Navy MARS activities. It will hit all the oddball frequencies and give me all of the output I need without a linear." — W9NZF

"I like the 1-kHz readout on the dial. It has the best sounding audio of any rig I have used, and it is super reliable. A real easy rig to operate." — K9BQL

"Selectivity, sensitivity, and calibration. I would buy another, if I could convince my XYL!" — WB2VXY

"Frequency coverage. Plug in a crystal and operate anywhere." — WA1PEL

"Reliability. I inadvertently left it on FULL TUNE (key down) position for almost two hours with no bad effects. In fact, I am still using the same finals." — WB4KCO

"Easy to tune and operate. It will cover any 200-kHz band between 3 and 30 MHz. *Very good receiver* front end. Excellent frequency stability, and rear skirt allows easy interface to other station equipment, such as RTTY." — WA9VYB

"I can always count on this rig to do what it is capable of without fail, without eccentricity or deviation — and do it rather well." — K5OCS

"Excellent engineering, very stable, good filter, and repairable. All parts can be worked on and replaced easily. It is only unfortunate that tube technology is phasing out so fast." — VE7AFJ

"Ability to withstand abuse. I have driven all over the U.S.A., including the desert Southwest, gotten dust and sand in it mobiling, accidentally overloaded it, mistreated it in almost any way you can think of short of dropping it out the window. It never has failed to operate." — WØRKU

"Solid investment — especially with today's stock market." — KA6ACD

"Longevity! This rig (serial #42) was purchased by my dad in 1959. It gave him 20 years' service until his becoming a silent key last year. The KWM-2, now in my possession, has since motivated me into earning my Novice ticket and I'm now struggling toward my General. I plan another 20 years' service from the rig." — KA6IYH

"The use of good components makes this the best unit I have ever owned since my first license in 1937. I'd say it's the best rig ever made for Amateur use." — K4FXP

"Maintaining this rig myself sure beats waiting for new solid state modules to arrive — or for factory servicing." — KH6BZF

the other side of the coin

Some of the very qualities that make the Collins KWM-2/2A so attractive to so many Amateurs are cited by other Amateurs as the radios' faults. The fact that the KWM-2/2A is solid and dependable also means that it's big and heavy in comparison with more modern, solid-state rigs. The fact that it uses tube circuits, which the Amateur can service himself, often without the help of professional service technicians, also means that those tubes will have to be replaced and the radio may put out a lot of heat. Because the radio was designed over 20 years ago, primarily for SSB use, it is less than ideal for CW: there is no CW filter position, and there is no R.I.T. And, hand *in* hand with its good resale value and the fact that the Collins name is widely respected, this transceiver is not inexpensive.

The worst feature most commonly cited in the KWM-2/2A was the relays. In earlier models, these relays were open (unsealed) and not of the plug-in variety. Dirty contacts were referred to by many of the respondents to this questionnaire. Several of the owners of the KWM-2/2A who wrote to us had replaced the original relays with plug-ins; in later models, Collins began using sealed relays, which

table 2. Worst features

	percent
relays	27
no CW filter position	16
bad CW rig because of frequency offset	11
heat	11
no R.I.T.	9
200 kHz per segment	8
high cost	7
faulty switches	5
RCA phono plug for antenna	5
no noise blanker	4
no internal supply	3
problems with bandpass switch	3
weight and size	2
microphone	1
delay in getting parts	1
broad signal	1

considerably cut down on the number of these problems. In most instances, a simple cleaning of the relay contacts and regular use are all that's necessary to get the rig working properly again. Another common complaint was that the KWM-2/2A is not a good radio for working CW, because of the frequency offset.

See **table 2** for the percentages. Below are some sample replies to the question, What is the rig's worst feature?

"Does not have a noise blanker built in. It should have a cooling fan for the 6146s (I added one on mine). Transceiver is a bit slow on recovery from transmit to receive. Also, the transceiver has no R.I.T." — WØRJ

"No supplied noise blanker. No CW filter position." — W3PE

"Only 200 kHz tuning capability per switch position (crystal)." — W4FDJ

"No good on CW because of 1.5 kHz shift in transmitted signal." — W3US

"The bandpass. There are no selectable options for the bandpass besides the 2.1-kHz installed. This situation becomes a problem when it is desired to copy 850-Hz shift RTTY signals. The high tone is then eliminated. Other than this, the narrow and steep sided bandpass characteristics are superb." — KH6S

"Requirement for external power supply and very long production lead time for parts." — WD4CWF

"Band switch was corroded and had to be cleaned. Even when it came back from Rockwell-Collins, the switch was corroded and had to be cleaned. Not easy if you have it on a rack." — WA6UZL

"It's no good on CW, and it needs a noise blanker. Only 200 kHz per segment, and it's hardly portable." — K6RK

"Initial high cost and factory cost for repairs." — K5NG

"I don't like being able to tune only 200 kHz at a time. And they use a phono plug connector for the antenna." — WA7ZPQ

"Not solid state. I hope the tubes for this rig do not become obsolete. The open relays in the VOX circuit collect dust. No notch filter or noise eliminator." — W5TTF

"The worst feature is the heat given off by the tubes — and the tubes' having to be replaced." — WB4PVT

"Difficult to troubleshoot and repair, and factory work is very expensive." — WB6ZYE

"There is no designed-in way to get narrower selectivity for CW reception, although Collins did point out that the transceiver was intended only for occasional, not serious, CW." — WØRHW

"Noisy VOX relays." — WB1FYV

"Band switch problems." — WB4NTM

"Weight and size. In the summer, it requires a small fan for cooling during extended periods of use: that is, over 30 minutes." — W2HBC

"RCA phono plug for antenna connection (should be BNC-type)." — K2QDE

"The fact that in this period the relays were not plug-in."

"Power consumption on battery source and lack of CW filter." — N7AA

"Poor CW break-in capability. Not too fast on recovery." — WB2VXY

"Not easily adaptable for mobile use." — WA1PEL

"If judged during its heyday, I can think of *none*. Now, of course, it lacks some of the little conveniences of the newer rigs: R.I.T., digital readout, power requirements, etc." — K5OCS

"VOX controls mounted inside chassis. Key jack is behind the rig and also covered by the power supply. And this radio is very expensive, even used." — KA6ACD

problems

The most common problem encountered with this rig was having to replace tubes. Take a look at **table 3** and you'll see that tube failures were by far and away the biggest problem. Several owners reported problems with shorted capacitors; and once more, relay problems show up as a main source of trouble for KWM-2/2A owners.

Nevertheless, the fact remains that most of the KWM-2/2A owners who responded to this survey were happy with their rigs and considered the problems to be minor. Many reported no problems. Here are some of their replies to the question, Have you had any problems?

"PTT relay contacts dirty." — WB6AWU

"Changed telephone-type relays to plug-in type." — K7GEX

"C187 shorted and the unit blew fuses. It required removing the band switch housing and band switch

table 3. Problems

	percent
tubes	42
relays	23
shorted capacitor	11
long wait for parts also high cost	6
band switch	5
VFO dial	4
VOX circuit	4
alignment	2
difficult to change components	2
AGC	1

shaft to replace. I occasionally have to replace tubes." — AH6U

"Just worn tubes." — HI3HEG

"I have a KWM-2 which has been almost fully modified to the "A" version. Occasionally (about once a year) the old wired-in relays give me trouble. I remove the M2 from its case, clean the relays, and it's good for another year. I do have the plug-in relay kit and plan to install it the next time the old relays give me trouble." — W3US

"Tubes and alignment." — WA6UZL

"VOX circuit erratic — had to change many components." — K6RK

"In over 20 years of use, I've replaced a few weak and shorted tubes. Original 6146s lasted nine years. Haven't had to change them since. Replaced one capacitor and one resistor!" — K5NC

"Tubes and heat." — K2OB

"Minor problems easily corrected by replacing a soft tube or tightening a loose screw. The equipment is so well made and logically constructed that it almost repairs itself." — KB9IY

"Mica capacitor in the i-f failed. Loose screw in the power supply shorted B+."

"The usual tube replacements." — K9LKA

"An intermittent receiver problem that has been hard to locate." — WD5CKA

"Had to replace the power transformer after ten years."

"Severe audio feedback when mic button released; corrected by cleaning all relay contacts with emery cloth — a very difficult job because my rig does not have plug-in relays." — WA1PEL

"VFO dial slippage." — WA2CBA

accessories

Table 4 shows the accessories purchased for the KWM-2/2A. A noise blanker was the most frequently mentioned item, followed by speech processors and amplifiers. It certainly does seem as though finding the wanted accessories is not much of a problem: 98.7 percent of the respondents who had purchased accessories had been able to find all the accessories they'd wanted. And 97.8 percent were satisfied with the accessories they purchased.

table 4. Accessories

	percent
noise blanker	13
speech processor	10
amplifier	10
external VFO	8
rejection tuning	8
mike	5
crystal pack	5
Q multiplier	4
digital display	4
dummy load	3
wattmeter	3
antenna tuner	1
transverter	1
SWR bridge	1

related findings

The beam antenna is by far the most popular antenna with KWM-2/2A owners, accounting for 55 percent of the tally. Next came wire antennas, with 34 percent, followed by all others, 11 percent. As for license class, there were a large percentage of Advanced-class hams represented, 57 percent, followed by 39 percent for Extras. Technicians, Generals, and Novices made up the remaining 4 percent. More than half of the hams who responded did their own servicing, and the majority of those who shipped the rig out for factory service were satisfied with the service they received. A few complained about a minimum parts order of $50 and delays in service or delivery.

The following twelve categories were scored from 1 to 10 (with 1 being poorest, 4 to 6 average, and 10 perfect): Ease of Operation, Reliability, Durability, Instruction Book, Factory/Dealer Service, Quality of Workmanship, Performance, Maintenance, Parts Availability, Accessories (ease of connection), Price, and Flexibility. The scores are reported in **fig. 1.**

would you buy one again?

This is the big question, and for the KWM-2 and KWM-2A the answer was that 73 percent said yes versus 27 percent who said no. That's a very good showing for a radio that was designed and built before the days of integrated circuits and modern "conveniences." Yet the KWM-2/2A continues to hold its own — and remains very popular. Of those who answered that they would not buy this rig again, the most common reason was the price, followed by the lack of modern, solid-state construction or "extras" found only on newer rigs. Not a single respondent faulted the Collins KWM-2/2A for lack of quality or workmanship. These transceivers were built to be solid and dependable — and they still are today.

Next month, *ham radio* will present the results of its survey of owners of the 32S-line transmitter and 75S-line receiver. Watch for it. And don't forget to return the questionnaire on the ICOM 701, Drake TR7, and Kenwood 520 series that appeared on page 22 of the February issue. If you own, or have owned, one of these rigs, now is your chance to tell the world what you think of it.

ham radio

digital frequency display for single-conversion transceivers

Update your rig for numerical frequency readout

Digital frequency displays are becoming commonplace in new transceiver designs. Older but still useful rigs lack this refinement. A digital display may be added easily to single-conversion transceivers such as those made by Swan and Atlas. The display described here will enhance operation of these rigs.

Frequency counters are in wide use, and it is quite easy to measure a CW transmitter's frequency. Single sideband is difficult, since a steady tone is required and you must find the carrier by adding or subtracting the tone frequency. Received-signal frequency measurement requires connection to the local oscillator plus mathematical operation on adding or subtracting the intermediate frequency.

common display methods

Nearly all transceivers use a single master oscillator or VFO for tuning both receive and transmit frequencies. A display can use this variable oscillator output, compensating for the i-f and any other fixed oscillators.

Digital display compensation can be made by heterodyning the VFO pickoff before counting, multiple gating and counting the VFO and fixed transceiver oscillator outputs, or presetting the display counter before a count. The last is the easiest to implement and is easily accomplished with single-conversion transceivers such as the Swan 350, 500C or the Atlas 180, 210, or 215X.

Any of the three methods require some form of bandswitching. Both the Atlas and Swan units add the i-f and VFO on 10, 15, and 20 meters and subtract the i-f and VFO on lower bands. The preset-counter method takes a bit of study.

preset and complement

Counter ICs such as the 74176 and 74196 can load a specific number into the counter before counting is done. This is *presetting* a state and is the same as addition: final count is the *sum* of the preset value and number of regular count pulses. An equivalent subtraction is possible by borrowing a computer technique called complementing.

When added to a *number*, a complement *will* yield a sum value equal to a difference. The highest carry is ignored. Since a count is desired in decimal, subtraction requires the tens complement. The minuend value remains the same; the subtrahend value is replaced by its complement, addition is done, and the resultant value (ignoring the last carry) is the same as the difference.

If you're confused, assume a subtraction that re-

By Everett L. Beall, K6YHK, 715 East Cook Street, Santa Maria, California 93454

sults in zero. The subtrahend will be the tens complement of the minuend. For example, the complement of 35 is 65, since $35+65=100$ (ignore the highest carry). The complement of 850 is 150 since $850+150=1000$ (again, ignore the highest carry).

Ignoring the highest carry is easy to implement. It is either unconnected, or the most-significant digit (MSD) of the display is blanked.

some examples

Setting up a Swan transceiver display counter on 20 meters requires addition. The preset, or load, will be 5500 kHz. For a six-digit display, the counter will accomplish:

load i-f	05500.0
add VFO	8502.2
display sum	14002.2

A 40-meter display requires subtraction of the i-f from the VFO. Conventional subtraction would be:

input VFO	12505.3
subtract i-f	5500.0
difference	7005.3

A preset counter can't subtract, so the complement of the i-f, 4500.0, is loaded first:

load i-f complement	4500.0
add VFO	12505.3
display sum	7005.3*

The asterisk indicates a blanked display digit. The actual sum is 17005.3 with a preset of 04500.0. The preset value could have any MSD value, since the display MSD is blanked (the counter's most-significant digit operation is ignored on low bands).

Atlas transceivers have i-f of 5520 kHz, so the low-band complement is 4480 ($5520+4480=0000$)*. Addition and subtraction by complements is the same as in the Swan example.

digital dial and display for the Atlas transceiver

Fig. 1 is the schematic. U5 through U9 provide the counter time base. Count gating and display control are generated by U1-U4. The counter chain uses 74176 TTL presettable BCD counters. The 74196 and 74LS196 are pin-for-pin compatible and may be sub-

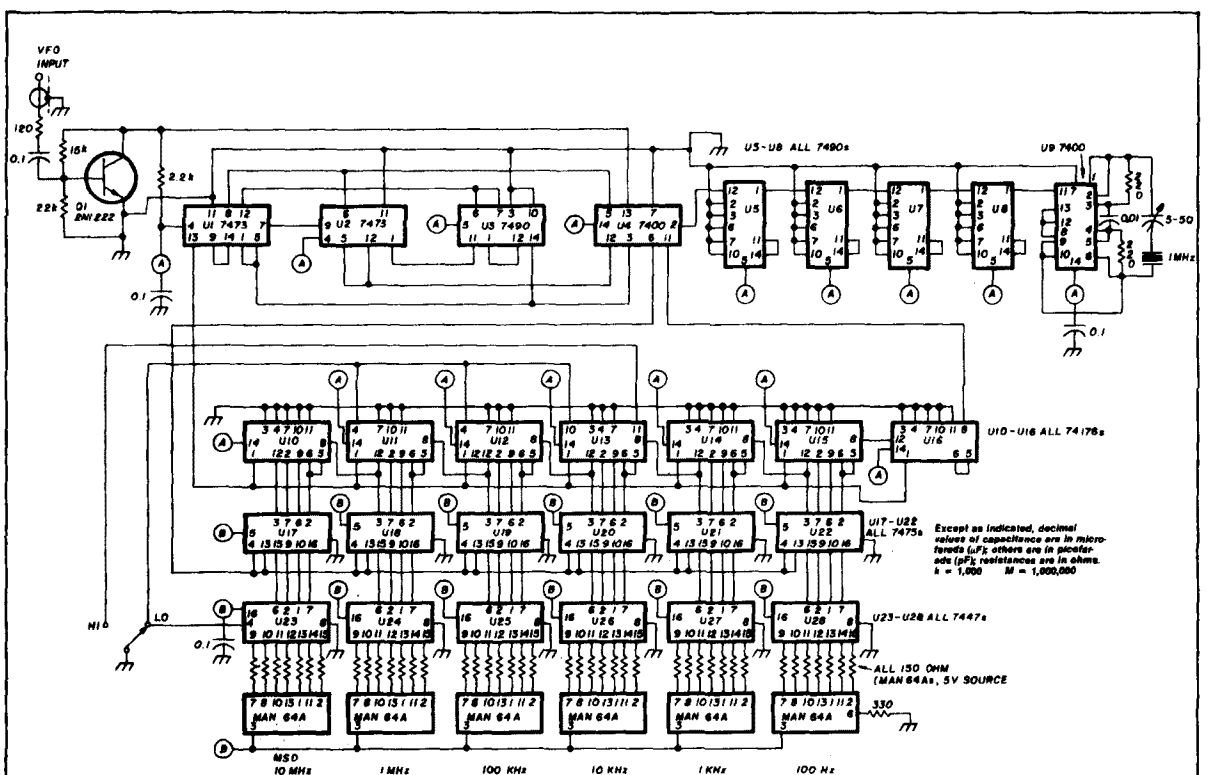


fig. 1. Schematic of Atlas transceiver digital display. Points marked *A* and *B* are 5 Vdc, regulated, from supplies in either *fig. 3* or *6*.

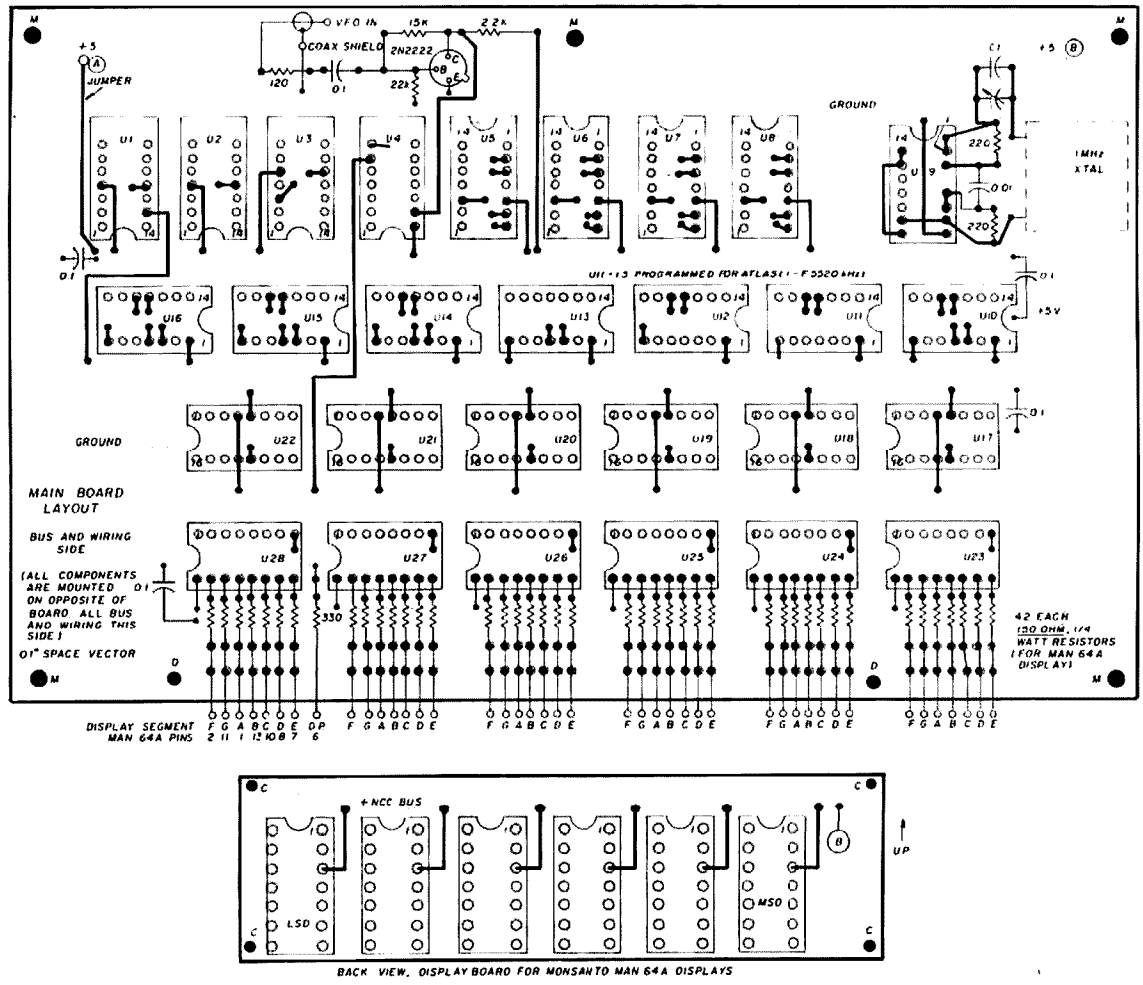


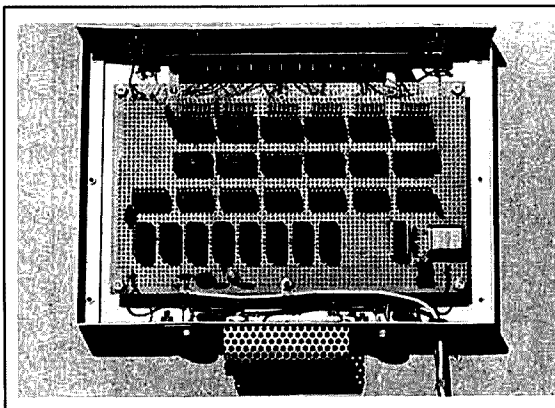
fig. 2. Bus and jumper wiring diagram, wiring side of main and display boards.

stituted. The 74176 consumes less current, and the 35 MHz maximum count frequency is well above any expected frequency.

Counter preset data pin connections are:

decimal preset	preset pin levels 11	3	10	4
9	1	0	0	1
8	1	0	0	0
7	0	1	1	1
6	0	1	1	0
5	0	1	0	1
4	0	1	0	0
3	0	0	1	1
2	0	0	1	0
1	0	0	0	1
0	0	0	0	0

A 0 indicates ground, or less than 0.4 volt. A 1 indicates any voltage between 2.4 volts and the 5-volt



Cover removed to show parts placement on perf board. Perforated metal cover on rear is used for protection from the heat of the series-dropping resistor.

supply. The high, or 1, state may be obtained by leaving the pin unconnected.*

The 7475 quad latches hold the counter state for display. Conversion to seven-segment LED display is through the 7447s. Grounding pin 1 of any 7447 will blank that digit display.

Monsanto MAN 64A common-anode, seven-segment LED displays were used, since they were in the junk box. Any common-anode LED with decimal point will work as well. The 150-ohm series resistors may have to be changed for different displays. Check manufacturer's specifications for proper value, allowing 0.4 volt at the 7447 driver output pins when a segment is illuminated.

internal sequencing and display

The time base counts down from a 1-MHz crystal oscillator, U9. The crystal is a Jameco CY-1A but may be any general-purpose crystal. The trimmer capacitor allows adjustment to WWV; a 5-50 pF range should be sufficient.

The 7490 dividers in U5-U8 are connected for symmetrical output. The divide-by-five output is connected to the divide-by-two input. Final output is 100 Hz or 10 millisecond period.

U1 through U4 must be wired directly as shown. This count and display control circuit is similar to the Atlas digital dial and provides a 100-ms count gate, count latch, and preset load in a non-overlapping sequence.

The 100-ms count gate allows 10-Hz counter resolution. Display is limited to 100 Hz resolution by omitting the latch, decode, and display packages for first-stage counter U16.

Counter preset data is always present but is not loaded until pin 1 of the 74176s goes low. A front-panel switch selects the proper preset. The HIGH position is for 10, 15, and 20 meters; LOW is for 40, 80, and 160 meters. This switch also controls MSD blanking of decoder U28.

layout and construction

Layout is not critical. The bus wiring diagram of **fig. 2** follows the schematic and signal-flow sequence. Perforated board with one-tenth-inch (2.5-mm) hole spacing is used throughout. Board wiring is by wire wrap, with sockets for all ICs and displays.

I've found that wire wrap is easiest for a single project. It permits easy changes. Adhesive-backed copper tape is used for power, ground, latch, and preset bus lines. Socket wiring is wrapped, then soldered to the bus strips. This technique eliminates the usual rat's nest of conventional wire wrapping.

*An unconnected TTL *input* will float to a high level but is susceptible to noise pickup; direct connection to +5 volts minimizes noise pickup.

The main board is 5 inches (127 mm) by 8 inches (203 mm).

The six-digit display board is 5-1/2 by 1-1/4 inches, (13.8 cm by 3.2 cm) attached to the main board with small brackets and No. 2 machine screws and nuts at holes marked **D** in **fig. 2**. Holes marked **M** are for mounting the main board in the enclosure.

Usual socket layout orients pin 1 in the same direction. Signal flow and bus strips required some modification of this rule. Use care in identification during construction. The 0.1-μF disc ceramic bypass capacitors should be mounted where shown.†

connection to the Atlas

Power requirements are 5 Vdc at 1.2 amperes. My display used 12 volts from the Atlas external oscillator socket (**fig. 3**). Two National LM309K three-ter-

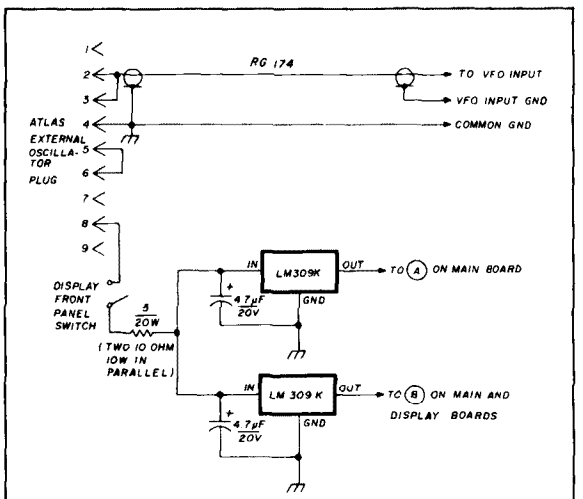


fig. 3. Atlas transceiver connections and power-supply regulator.

minal regulators were used, the outputs divided into **A** and **B** power connections of **figs. 1** and **2**. The 5-ohm dropping resistor reduces regulator dissipation. It is mounted inside the perforated metal cover at the display enclosure back panel.

The Atlas requires a nine-pin miniature vacuum-tube plug connector. I used a Pomona Electronics TVS 9 tube-test adapter. Originally used for tube-circuit testing, it has solderable lugs on the socket end.

packaging

No miniaturization was attempted. The enclosure,

†If possible, use several 0.01-μF bypasses, distributed evenly along power and ground buses, which reduces the possibility of digital noise entering the receiver.

which is 9-1/2 inches (24 cm) wide and 6-3/4 inches (17.1 cm) deep, fits nicely on top of an Atlas cabinet. Shown in fig. 4, this homemade enclosure uses aluminum sheet plus angle stock for strength and joining the cover.

Metal spacers and No. 4 screws hold the main board to the bottom section. Since I used 1/2-inch (12.7-mm) spacers, the wire-wrap posts had to be trimmed after wiring to prevent shorts. Height may be increased to eliminate trimming or to include a power supply.

Power regulators and the dropping resistor are mounted on the back surface. The resistor cover prevents possible burns. Wiring from the Atlas is made directly into the display.

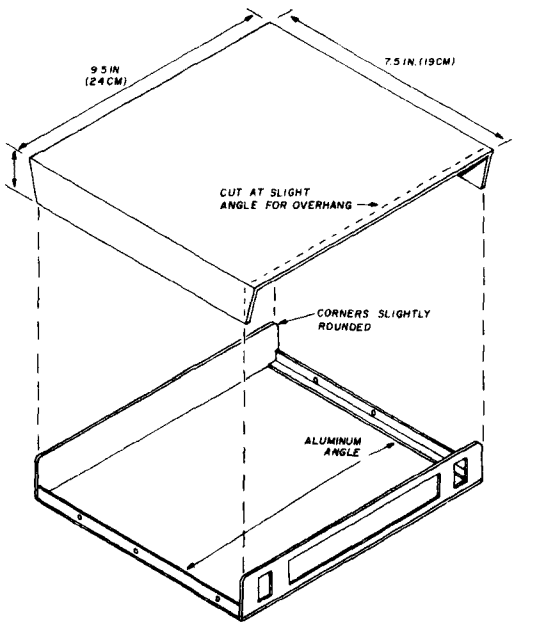


fig. 4. Enclosure as seen in the photographs. Aluminum sheet 0.05 inch (0.050 cm) used for bottom and top. L-angle stiffeners are 1/2 inch (1.3 cm) which are available at hardware stores.

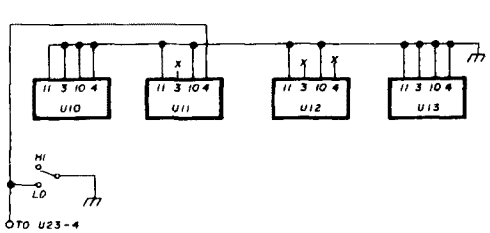


fig. 5. Swan transceiver preset connections. U14, U15, U16 connections are the same as in *fig. 1*.

modification for the Swan transceiver

Preset connections must be changed for the Swan's 5500 kHz i-f, and this information is given in fig. 5. Pins 4, 10, 2, and 11 of U14 through U16 remain grounded. External oscillator connection and power-supply arrangements are shown in **fig. 6.**

The ac-input supply may be used with any transceiver and installed within a larger display cabinet. Only one series regulator is required with the ac supply; LED display power is taken unregulated from the transformer center tap.

A Swan display could use the power supply from either **fig. 3** or **fig. 6**; choice depends on primary power at installation.

preset options

The tens complement method is limited to single-conversion and certain VFO ranges. Some situations may use the *nines complement* for the MSD preset. The nines complement is equal to the tens complement minus one. One situation is indicating 12 MHz with a 15-MHz VFO.

The tens complement method would display 22000.0 or 2000.0* with MSD blanked. The added

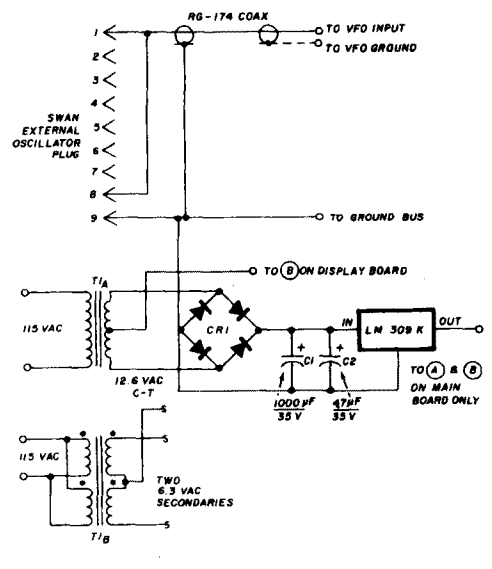


fig. 6. Swan transceiver connections and optional ac power supply. Part numbers indicated are available in Radio Shack stores.

complement would be 07000.0 and obviously wrong. Changing the MSD to nines complement, or 97000.0, would correct this:

load mixed complement	97000.0	
add VFO frequency	15000.0	
display sum	12000.00	(MSD carry ignored)

Modifications of the preset can be included to correct slight frequency errors in a VFO. Grounding all presets allows direct frequency measurement subject to the accuracy of the time-base crystal oscillator.

summary

In this day of synthesizers, built-in digital displays, and other refinements, it's still possible to update good equipment. This isn't a beginner's project, but it can be built by an experienced homebrewer. Options are possible. An added incentive is low cost.

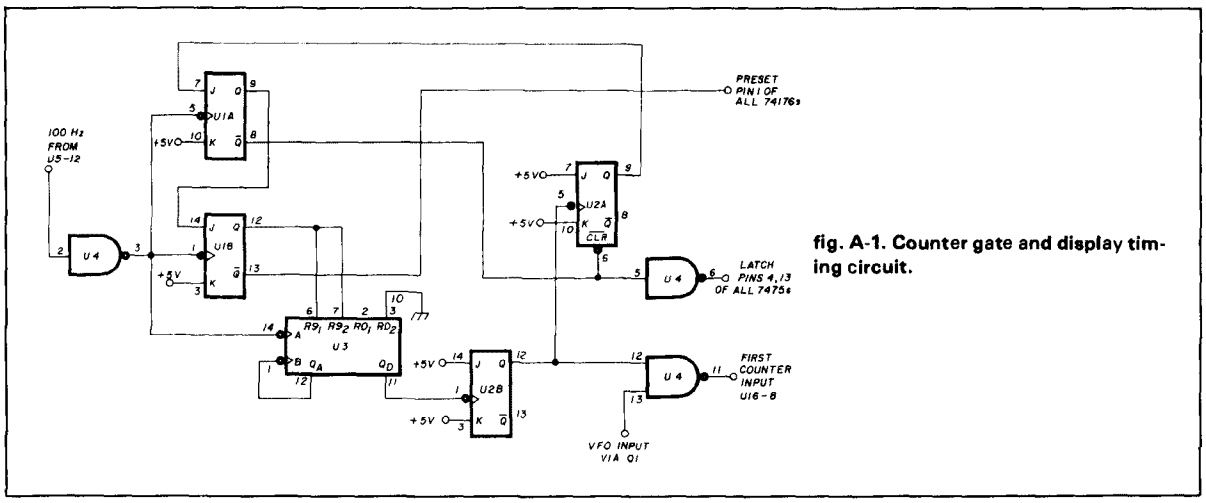


fig. A-1. Counter gate and display timing circuit.

appendix

This material is included for clarification of the only complex part of the digital display — the count and display control. This circuit has been breadboarded as well as analyzed. It works up to 1 MHz input without trouble.

The digital display operation depends heavily on proper operation of U1 through U4 (**fig. A-1**). Operation of this circuit is detailed as an aid to trouble-shooting and to illustrate variations in digital circuit designs. This section controls the counting gate, latch, and preset sequencing automatically.

The timing diagram begins with decade counter U3 in a decimal 9 state. U2-12 is low, inhibiting the U4 VFO count gate and holding the counter chain and display idle. The first negative edge from U4-3 will toggle U3 from 9 to zero. U3-11 will go low and toggle U2-12 high; counting begins.

After ten negative edges of U4-3, or 100 milliseconds, U3-11 will go low again. U2-12 will toggle low, inhibiting the VFO gate and toggling U2-9 high. Both U1-9 and U1-12 have remained low due to the low J input at U1-7 from U2-9; both sections of flip-flop U1 are connected as a shift register.

The next negative edge from U4-3 will toggle the first stage of U3 high and toggle U1-9 high, U1-8 low. U1-12 is ready to toggle on the next clock pulse from U3-4, but more significantly, U2-9 is cleared low by the low state of U1-8 into the direct-clear input, U2-6. The LATCH bus goes high through the inverter connection of U4-5,6 and all of the 7475 latches store the full counter state.

The following negative edge from U4-3 will toggle U1-12 high and force U3 into a decimal 9 state through the R9 control pins. The 7490 used for U3 will be held in the decimal 9 state until pins 6 and 7 go low. The first stage of U3 will toggle low and remain for 15 to 20 ns until forced high; flip-flop delays account for the negative spike.

If U1-12 is high, then U1-13 will be low and counter PRESET is enabled. Counters assume the preset connections, but the latches hold the previous count due to U4-6 dropping to a low state. U1-9 is now low and sets up U1-14 J input for the next clock edge.

The last clock will toggle U1-12 low and remove the forced 9 state of U3. U3 does not toggle, since the forced condition will have been still present at the clock edge arrival time. U3 remains in a 9 state, and all flip-flop Q outputs are low. The counter and display are idle.

The cycle will start again on the next clock edge. Display update occurs every 140 milliseconds, about seven per second.

Take care not to confuse pins 8 or 9; 12 or 13 of both flip-flop packages. An improper connection will cause a short cycle and false display; possibly no display at all.

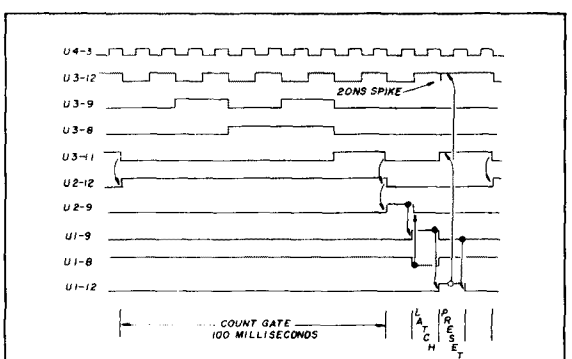


fig. A-2. Counter gate and display timing diagram.

ham radio TECHNIQUES

Bill Orr W6SAI

more about moonbounce

My last column was an introduction to "moonbounce" (earth-moon-earth) communications — the past history of it and the way Radio Amateurs use this exciting means of communicating. One important point I stressed is that EME is totally unlike the more common modes of communications in that the parameters required for moonbounce work are well known and the beginning moonbounce enthusiast can make the larger, more well-equipped stations work for him, thus taking a portion of the communications burden off his back!

The Amateur bands between 6 meters and 1296 MHz have been used for moonbounce work. The most popular bands for this up-and-coming mode are 144 MHz and 432 MHz. There seems to be more activity on the 2-meter band, and the station requirements for this band are well established. This column limits discussion to 144 MHz moonbounce operation.

A representative EME path is shown in fig. 1. If two operators can see the moon at the same time, the path is available for contact. For general operation, EME operators aim for a "window in the sky" called the *universal window*, an area in the sky in the path of the moon through which most operators can see the moon. Most moonbounce activity occurs when the moon traverses the window.

The round-trip antenna gain required under ideal conditions on 144 MHz is very close to 41 dB. This means that a moonbounce operator having an antenna with a power gain of 21 dB over a dipole should be able to hear his own moon echos and should hear other moonbounce stations having 21 dB of antenna gain, or more.

Since the round-trip gain is supposedly constant, stations having an antenna gain less than 21 dB can't hear their own echos but can hear other

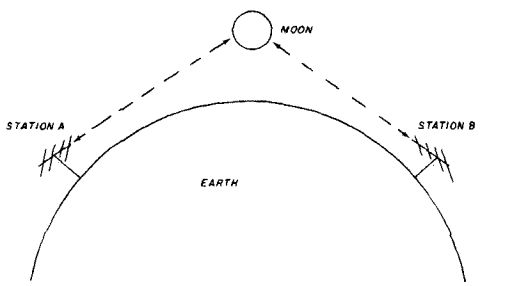


fig. 1. The earth-moon-earth communications circuit. Stations beyond the curvature of the earth communicate on vhf bands by reflecting their signals from the moon.

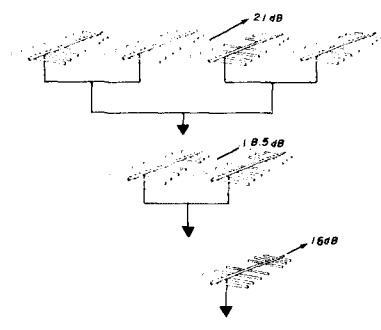


fig. 2. Combining Yagi antennas provides enhanced gain. Doubling number of antennas raises gain by about 2.5 dB. Eight 16-dB antennas, for example, can provide a power gain of 23.5 dB.

stations having more than 21 dB of antenna gain. A station having an 18-dB gain antenna, for instance, should be able to hear and work moonbounce stations having an antenna gain of 24 dB. Exceptions to this rule make moonbounce very exciting.

Several commercially available 2-meter Yagi beams have a claimed signal gain of over 16 dB. Taking this as par, then, how does the beginning moonbouncer build up a practical EME array? Well, the 16-dB antenna can hear other moonbouncers having an antenna gain of 24 dB. Enough moonbouncers have arrays of this size to make a 16-dB antenna marginally acceptable for a moonbounce contact. The biggest moonbounce arrays that I know of in everyday use run about 26 dB over a dipole. Once in a while hams in research establishments obtain permission to put a "big dish" (parabolic) antenna on the air for moonbounce work. And that provides a moon-reflected signal that will knock your ear off!

how to achieve moonbounce antenna capability

How big must the moonbounce array be to provide practical EME work? A 16-dB antenna will permit contact with a few stations. If two 16-dB antennas are combined properly to form a larger array, the overall gain will be increased by about 2.5 dB. If four arrays are combined, the gain will go up another 2.5 dB. Two arrays, then, provide 18.5 dB and four provide 21 dB. Suitable antenna combinations are shown in **fig. 2**.

Many moonbouncers settle for four arrays as this configuration is not too bulky and the feed system is not complicated. Some of the ardent DXers use as many as 24 antennas in a four-by-six arrangement — yet many enthusiasts use only one or two arrays.

Some of the factors to be considered when building a moonbounce array are as follows.

Distance to the moon. The distance to the moon varies because the moon's orbit is an ellipse. At *perigee* (the closest point) the moon is about 221,400 miles (354,240 km) from the earth and at *apogee* (the farthest point) the moon is 252,700 miles (404,320 km) away. The path difference is about equal to 2 dB, so it pays big dividends to use the moon when it is closest to the earth.

Sky noise. This phenomenon refers to background noise that may limit reception. There are a lot of radio noise sources in space. The sun, for example, is a prolific radio-noise generator. Certain stars are radio-noise sources, too. A noisy star in line with the moon can override weak moonbounce signals. Wise moonbounce operators operate when the moon is in a quiet portion of the sky to reduce competition from unwanted noise.

Faraday rotation. A puzzlement to early EME experimenters was the mysterious loss of signal caused by polarization rotation of the signal as it passed through the earth's atmosphere. Many simple moonbounce antennas are fixed as far as polarization goes, and the operators must patiently wait until polarization aligns itself with their antennas before contact can be established.

In addition, atmospheric effects can blur the signal (*scintillation*) and the rough surface of the moon causes *libration fading*. All of this means that sometimes moonbounce communication is almost impossible, and at other times signal strength is so great it cannot be explained.

But to plan a moonbounce station, a certain set of normal conditions must be taken, and the overall situation is not as gloomy as it might sound. To begin with, a single 16-dBd Yagi antenna will suffice if the beginner wishes to listen for some of the more well-equipped EME stations. Two 16-dBd Yagis will provide improved capability and allow two-way communication with the better moonbounce stations. Four Yagis will provide good EME capability. And from this point, the moon's the limit!

moonbounce station equipment

Before leaving the discussion of the antenna it should be pointed out that *feedline loss* plays an important part in EME work, and it should be held to as low a value as possible. The length of the line should be short and the antenna mounted near the equipment. Contrary to what is required for ionospheric-reflected DX work, height is not important for EME work as long as the antenna can clearly "see" the moon. Many moonbouncers place their antenna right outside the operating room. In some cases a good grade of RG-213/U or RG-8B/U cable is used, or else the larger, more expensive RG-17/U cable. The better-equipped stations use air-dielectric coaxial line for minimum loss.

Some deluxe moonbounce stations locate the receiver preamplifier and transmitter power amplifier directly at the antenna to eliminate feedline loss. I don't recommend the beginner attempt this, but it illustrates the attention to detail that makes a successful moonbounce station.

Progressing down the feedline, the *antenna relay* is a critical item. The relay must provide adequate isolation of the receiver during periods of transmission. The very sensitive devices used in EME preamplifiers cannot stand seepage of rf from the transmitter around the relay contacts. Many moonbouncers use two separate antenna relays, one to switch the feedline and the second to ground the input terminals of the receiver preamplifier for protection.

Next item to consider is the station receiver. A good, *low-noise preamplifier* is required. The *receiver* may consist of an hf receiver with a 2-meter converter in front of it. The receiver should be equipped with a *narrow-band filter* such as used for CW reception. This will provide the best signal-to-noise ratio and enhance the operator's ability to hear weak signals. A passband of about 500 Hz is a good compromise.

Finally, the transmitter must be considered. While moonbounce contacts have been made on rare occasions by stations using as little as 200 watts output, a practical moonbounce station calls for 1 kW input, with about 700 watts going into the antenna system. Maximum power, of course, provides the greatest margin for success.

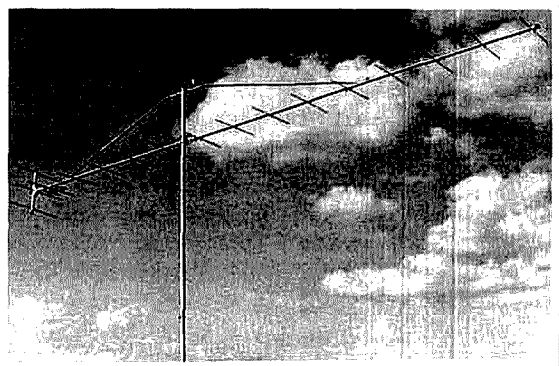
In addition to the transmitting and receiving equipment, the practical EME station requires an accurate clock. A tape recorder is very handy for recording received signals. And finally, if the moonbounce antenna is steerable, the operator requires alignment information to aid in finding and tracking the moon.

With a tracking antenna and lunar orbital information, the moonbounce operator is able to plan his operation into the future and arrange schedules with other enthusiasts. The *Nautical Almanac* provides lunar information in terms of the *Greenwich Hour Angle* (GHA) and, unless the operator lives in Greenwich, England, he requires a second publication which converts this information into usable data. And, finally, the longitude and latitude of the station must be known.

A helpful handbook which discusses all of this information in detail is *VHF Radio Propagation*, by J.D. Stewart, WA4MVI (book number 21575) published by *Howard W. Sams & Co.* and available at many Amateur Radio distributors and from Ham Radio's Bookstore, Greenville, NH 03048 ($4.95 plus $1.00 shipping).

a day in the life of a moonbouncer — K1WHS

(This is the story of Dave Olean, K1WHS, an active moonbouncer. Dave uses an array of twenty-four large Yagis to provide a power gain of over 26 dBi on 2 meters. This is an actual account of Moonbounce DX using this super-big antenna).



One of the "Boomer" antenna arrays of the type used by K1WHS in his moonbounce antenna.

The alarm clock sounds like Big Ben. I awake with a start in the blackness and fumble around to silence the noisemaker. Ah, yes. Tonight is the Universal Window. Saturday morning, 2 A.M. on the east coast. A lot of Europeans will be on 2 meters looking for moonbounce contacts.

Up and at 'em. Wringing the sleep from my eyes, I head toward the shack. I flip on the lamp, view my schedule list and check the clock. The big antenna array of twenty-four Yagis rotates around to intercept the moon at the touch of the controls. The equipment has been running and warm all night in anticipation of this moment.

With a yawn I slip on the earphones, key the 2-meter transmitter, and adjust the drive level for 100 watts output. The SWR on the transmission looks good. All seems to be in order. I send a few dots and switch to receive. Yes! I am greeted by a nice moon-reflected echo of my signals that have just made the 450,000 mile (720,000 km) round trip.

The moon is at perigee, or the closest point to the earth. I know this can make a big difference when a small, marginal moonbounce antenna is being used on one end of the EME circuit. Path loss can increase by 2 dB between perigee and apogee, and this can spell success or failure with a marginal antenna.

All right. I scan the 2-meter band between 144.000 and 144.015 MHz and hear a few signals. They are coming back at me from the moon. WA1JXN/7 is calling CQ on 144.007 MHz. Lance is about two and one-half S units above the background noise and very steady. Good copy. That's a good sign!

Some days the lunar-reflected signals are very "watery" and subject to severe, rapid fading. Such conditions tend to frustrate avid moonbouncers. Stations with small antennas may have a hard time making any contacts at all during a period of disturbed conditions. Not so this evening. Tonight the band sounds perfect! Even the galactic background noise is cooperating. Very little excess noise means signals will be strong and clear.

By this time my first schedule with DL8GP in Germany is about to begin. I tune the receiver to 144.030 MHz and zero-beat my transmitter frequency as close as possible. Wow! I'm hearing his signal!

"K1WHS DE DL8GP...K1WHS DE DL8GP..." He's there. Over and over I hear the two calls, clearly. After two minutes he signs over to listen for me. I transmit calls back for a minute and a half, then in the last 30 seconds I send the letter O several times, to signify that full call sets have been received. That's moonbounce shorthand many stations use.

I stand by and DL8GP answers with more moonbounce shorthand: "R-O-R-O" meaning OK, call sets received. Another moonbounce DX

schedule logged. His signals have been quite steady the whole time. I let him go to work other moonbounce stations looking for a European contact.

The moon at this point is about one hour away from setting in central Europe. I touch up the antenna rotors to peak the array on the moon. A beamwidth of less than 6 degrees means a lot of antenna tweaking to stay on the moon. I generally update my headings every six or eight minutes.

What else is going on? I think 144.004 is clear for a CQ. I am "looking" toward the east and, by convention, should transmit during the even two-minute periods of the hour. As I reach for the key, VE7BQH and WBØQMN both come on calling CQ, about a kilohertz apart. Both signals are of unbelievable strength, considering they are coming at me from the moon. It is hard for a moonbouncer to comprehend the signal levels as received on such a large antenna array. Both Tom and Lionel are S6 on peaks, the receiver meter bouncing with a little libration fading. I quickly drop the idea of sending a CQ and decide to call WBØQMN. To my surprise he doesn't come back! This occurence, I say to myself, is a perfect example of the K1WHS moonbounce theorem: Namely, that if a signal is loud enough to roll your socks up and down on 2-meter moonbounce, the operator will not even detect your signal! Sort of a vhf version of Murphy's Law.

Back to the idea of a CQ. I move up the band a few kHz and send a short call. Wow! A pileup calling me! This is difficult, as all signals are zero-beat and all about the same strength! Sort of like 20 meters, I say to myself. Through the din I can make out...I4 (Italy) and W...DU. The other calls are lost. After two minutes, I've just been able to pull out one complete call...here it is: HB9QQ (Switzerland)!

I'm really surprised, as the Swiss station is a new one I've never heard before. I've tried schedules with him off and on since 1976 with no luck, and now here he is, big as life! The big, 24-Yagi array does the job, and I pick him out of a moonbounce pileup on a CQ. Times do change on vhf! Pierre is running about 339. A good signal. He gives me 539 and we sign off.

Time for another CQ? No, sked-time with G4IDR in England is coming up. This will be a tough one as he's only running a single long Yagi and 400 watts. He can only aim at his horizon since his Yagi is used mainly for tropospheric and meteor scatter work. But now his setting moon is in line with his antenna and the prearranged sked time is upon us.

Watching the sweep second hand on my clock, I begin my calling sequence and pause between characters to listen to my own echo. It is very strong. Now, I listen for Dave, G4IDR. Nothing. I wait for two minutes and start calling again. Half-way through my calling period I detect a signal during the keying sequence. It is very, very weak and sounds like background flutter.

The signal builds up slightly. I hold my breath and close my eyes...an old trick which seems to concentrate hearing comprehension. Parts of a call come through "...1WH...4... DR."

In my next calling sequence I start sending the letter M in the last 30 seconds. This told Dave I was getting parts of his call. Now, I again listen and Dave's moonbounce signal picks up a bit to allow a few sets of calls to sneak through, then a slow, gradual slide into the background noise begins. Faraday rotation has struck again!

From experience I know it will be at least ten or fifteen minutes before I hear him again. I send a batch of Os to G4IDR, telling him I have received the call sets. Moonset in Europe for G4IDR is 0812, and at 0800 I start to hear him again after a 40-minute lapse. Excitement builds as I strain to hear him. I figuratively crawl down the earphone cord. He is building up, now...at 0804 he is much stronger, in fact, now moving the S meter! The whole 2-minute sequence is nearly Q5 copy.

I acknowledge his transmission with enthusiasm, stopping at 0810 as I know he's lost my signals.

Suddenly, the telephone rings and I jump involuntarily. None other than Dave, G4IDR, is on the line from England! He's so excited he can hardly talk. He was running 400 watts output into a single, 19 element Boomer Yagi. But the surprise was that he had removed the front six feet of the boom and the associated elements so that he could turn the antenna in his small yard. He had a 3-dB loss in his feedline, moreover, giving him only 200 watts into a "lobotomized" Yagi beam! I exchanged excited words with him, set up a new sked, then turned back to the receiver for more listening.

The moon has set in Europe, so I switch my calling period from even 2 minutes to the odd ones and call CQ. There's WBØQMN coming back, weak but readable. I answer Tom and give him a 339 report. No reply. Where did he go? Another call. No reply.

As I start to call again, the phone rings for the second time. It is Tom, WBØQMN.

"Do you know what you just heard?", he asks. "I was running my 10-watt exciter into my moonbounce array! Ten watts! I nearly fell out of my chair when you came back. I decided you must be working someone else and that my ears tricked me. So I didn't reply. Then when you called again..."

"Surely the QRP DX report of the century," I replied. "No way to top that one."

The moonbounce DX session was over by now. The moon "window" was closed. I flipped off all the control switches and headed up the stairs for a quick wink of sleep before I had to go to work. Not a bad "DX window" for 2-meter moonbounce work. Too bad I didn't get the Italian station. Maybe next time...

ham radio

genesis of a synthesizer

Design and construction of a low-cost 2-meter synthesizer

Several years ago, after purchasing an inexpensive 2-meter rig for the car, I realized that crystals for this new toy were rather expensive. If I loaded up all 23 channels I would have more invested in quartz than in the rig! Clearly, a synthesizer was needed, and so the search for ideas began.

A search of the literature revealed that most designs used TTL, consumed lots of power, used two (or three) crystals in a mixing scheme, and could be improved upon with a dash of newer technology.

Next, some design objectives were laid down. These were the following:

1. Coverage of the entire 2-meter band in 5-kHz increments

2. Adequate output drive at 12 MHz (transmit) and 45 MHz (receive)

3. Switch-selectable offsets of +600 kHz, −600 kHz, or simplex operation

4. Low power consumption (less than 250 mA)

5. Good temperature stability, small physical size, and low cost (less than $100)

Happily, these objectives have been met, and the result is what follows.

system design

Referring to fig. 1, the system block diagram, we see that the reference frequency for the phase detector is derived from a very stable 6.82666-MHz crystal oscillator. This signal is divided by 4096 to provide the 1.666-kHz reference frequency. The phase detector output is smoothed to dc by the loop filter and controls the VCO frequency. This frequency is divided by 2 before being applied to a divide-by-N counter. N is determined by the settings of the thumbwheel switches and the choice of offset.

The divide-by-N counter output supplies the second input to the phase detector, closing the feedback loop. The receive and transmit outputs are the VCO frequency and the VCO frequency divided by four respectively. This scheme was the simplest I could devise consistent with my needs. Now, let's fill in the blocks.

how it plays

Refer to the schematic, **fig. 2.** It was suggested to me that, for best frequency stability, the reference oscillator should be in the 5-10 MHz range. For this reason, the crystal is a 6.82666-MHz unit, cut for 30-pF load capacitance. U1, a CD4060B containing the oscillator circuit and an on-chip divide-by-4096 counter, provides the 1.666-kHz reference. (Note the heavy temperature compensation.) Also, the load capacitance can be adjusted slightly to offset the crystal frequency for +5 kHz channel spacing. Zener regulation provides excellent stability over an 11-15 volt supply range.

The desire for low-power consumption made the MC14046 (or RCA CD4046) a logical choice for the phase detector. The loop filter was adapted from the design of DJ2LR[1] and was designed to provide a worst-case settling time of about 50 ms. The output of the loop filter controls the frequency of an MC1648 VCO, tuned by an MV104 varactor. A 2N2369, Q1, converts the VCO output (an ECL square wave) into a TTL-compatible signal to drive the output buffer and divide-by-four circuits.

This signal is divided by two by U14, an SN74S74

By Ken Grant, VE3FIT, 46 Merryfield Drive, Scarborough, Ontario, Canada M1P 1J9

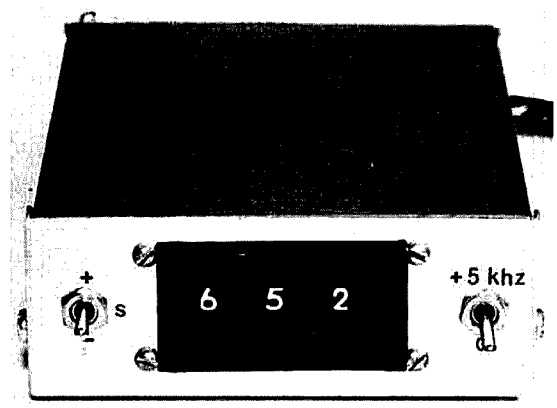
flip-flop. The flip-flop output is then level-translated to clock U15, an MC12013 dual-modulus prescaler. U3-U8, and U15, form the divide-by-N counter. Note that, since the MC12013 output is at ≈2.5 MHz, subsequent stages can be relatively low-speed CMOS devices. The divide-by-N arrangement divides the VCO signal down to 1.666 kHz for the phase detector. It's based on the scheme used by K4VB and WA4GJT.[2]

The divide-by-N counter is programmed in two ways: first, according to whether you're in transmit or receive mode (Q4 and associated circuit); second, by U9-U12 in conjunction with the thumbwheel switches and the transmit offset selection toggle switch, S2. U9-U12 form a two-decade BCD adder/subtractor capable of adding 0.6 MHz (600 kHz), or zero MHz, or subtracting 0.6 MHz from the thumbwheel switch settings.

Finally the 12- and 45-MHz signals are gated and buffered by U16 to provide low-impedance output drive. (Gating the output signals on or off helps to reduce overall current consumption.) A LM340T-5 provides regulated +5 volts for all the non-CMOS logic.

construction

As you can see from the photos, the unit is very compact. All the CMOS circuits are mounted on a piece of Veroboard measuring 3.25 by 3.25 inches (8.3 by 8.3 cm) and are supported by four 0.25-inch (6.5-mm) standoffs. The remaining circuitry is on a double-sided PC board measuring 2-7/8 by 2-7/8 inches (73 by 73 mm). A resist pen was used to make the circuit trails.



Completed synthesizer. Unit is a compact 4 by 5 by 1.5 inches (10 by 13 by 3.8 cm).

The circuit paths are etched on the top of the PC board, and the bottom is left unetched for a ground and to shield the more sensitive circuit from any CMOS switching garbage.

Be sure to remove a small area of copper (using a small drill bit or deburring tool) from the area around the holes where any ungrounded components protrude. In addition, I fashioned a piece of thin copper into a VCO shield. Be sure that it's grounded! The general circuit board layouts are shown in fig. 3.

Feedthrough caps (500 pF) filter any rf from the PTT and +12-volt lines, while the transmit and receive outputs are taken from a pair of phono sock-

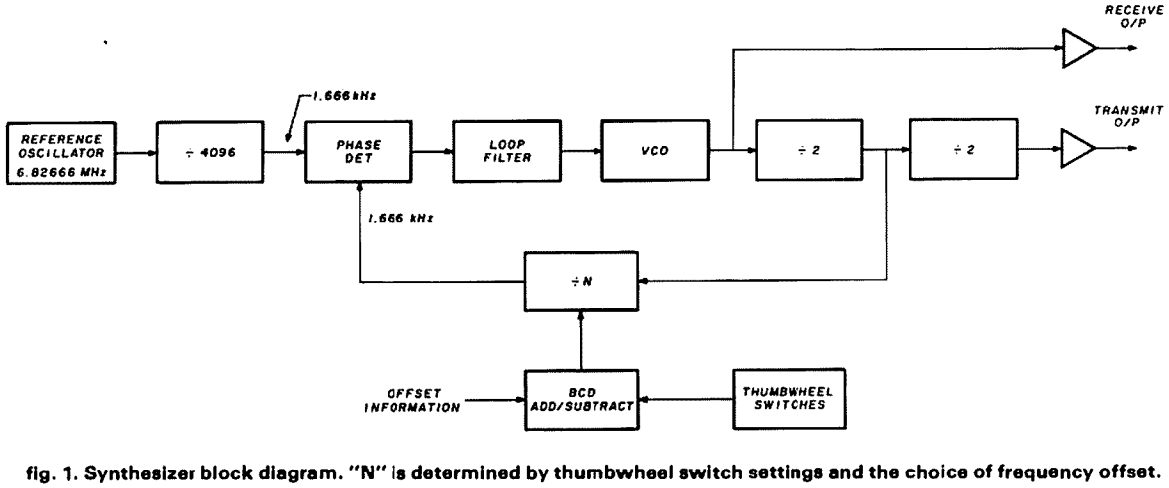
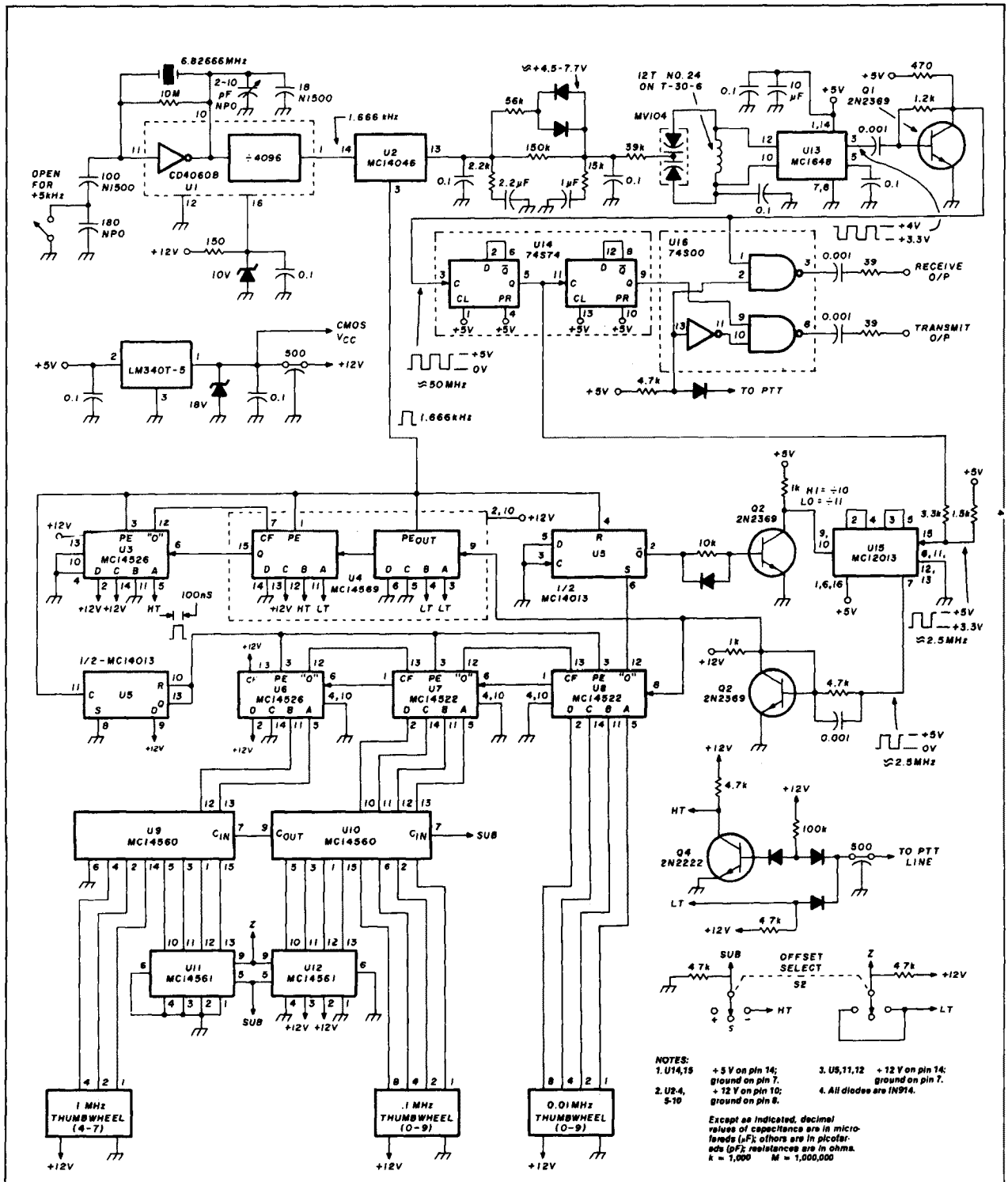


fig. 1. Synthesizer block diagram. "N" is determined by thumbwheel switch settings and the choice of frequency offset. The entire 2-meter band is covered in 5-kHz increments.



NOTES:
1. U14,15: +5 V on pin 14; ground on pin 7.
2. U2-4, 5-10: +12 V on pin 10; ground on pin 8.
3. U5,11,12: +12 V on pin 14; ground on pin 7.
4. All diodes are IN914.

Except as indicated, decimal values of capacitance are in microfarads (µF); others are in picofarads (pF); resistances are in ohms. k = 1,000 M = 1,000,000

fig. 2. Schematic diagram of the 2-meter synthesizer. Reference oscillator operates in the range 5-10 MHz for best stability. Crystal is cut for 30-pF load capacitance.

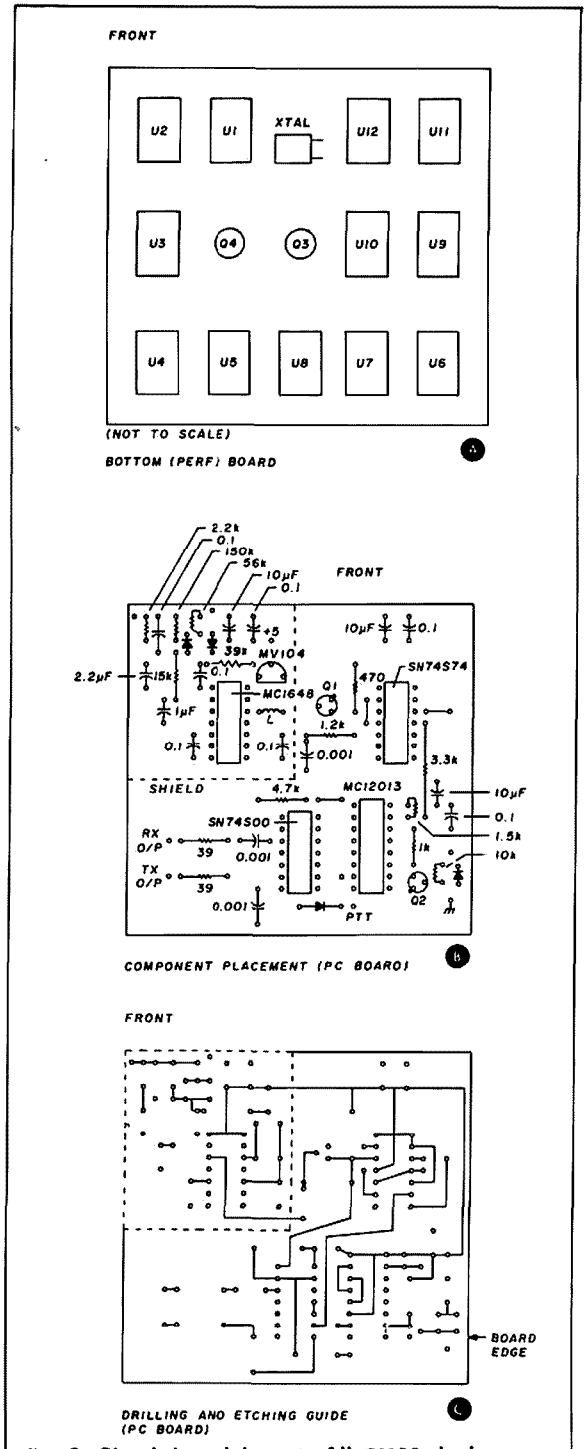
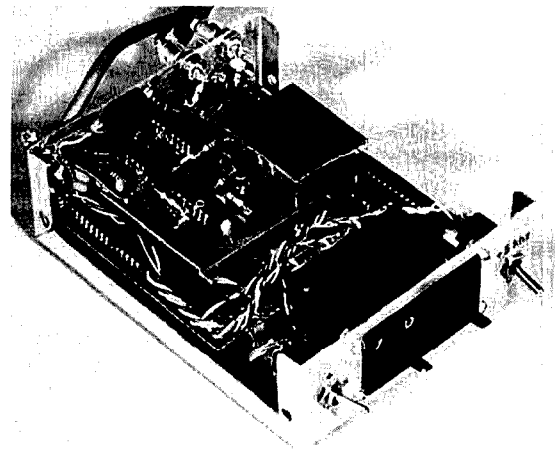


fig. 3. Circuit-board layout. All CMOS devices are mounted on a piece of Veroboard (*A*). (The American equivalent is Vectorboard No. 3682-4.) Interconnections on this board are made using No. 30 (0.25-mm) insulated wire on the underside. The PC board, (*B*) and (*C*), is double-sided copperclad. The bottom is left unetched to serve as a ground plane and shield. Circuit trails, made with a resist pen, are on top.



Inside the 2-meter synthesizer. All CMOS circuits are mounted on a piece of Veroboard and are supported by four standoffs. Remaining circuitry is on a double-sided PC board.

ets. The 5-volt regulator is bolted to the rear of the case for good heat dissipation.

checkout and alignment

After all of your wiring is done, I suggest checking all the interconnections with an ohmmeter. This doesn't really take too long and often saves a lot of time later on.

Once you're satisfied that all is in order, set the thumbwheels and toggle switches for 144-MHz simplex. Ground the PTT line and apply power. If all is well, you should be drawing about 200 mA and there should be a 12-MHz waveform at the transmit output. Lifting the PTT line from ground should cause a 44.433-MHz signal to appear at the receive output.

If all isn't well, start a check with your oscilloscope probe, starting at the reference oscillator and working your way around the loop. Finally, use a frequency counter to adjust the crystal oscillator right onto frequency. Check for proper operation of the transmit offsets (remember that the thumbwheel switches show the received frequency). Opening the +5 kHz toggle switch should shift both receive and transmit outputs by the equivalent of 5 kHz at 144 MHz.

installation

Only five connections are required between the synthesizer and your rig. These are: +12V, ground, PTT line, and receive and transmit inputs. The latter two should be coaxial cable. Try to terminate both coax lines with somewhere between 50 and 100 ohms. K9LHA provides excellent interfacing suggestions in his article.[3]

A common occurrence in outboard synthesizer installations is one of vhf rf coming back into the synthesizer through the two interconnecting coaxial lines. My setup was such a case, and the results were very evident — nobody could understand a thing I said for all of the squealing and hum! The cure was to install a pair of in-line lowpass filters, thus stopping the vhf rf before it can get inside the synthesizer. Circuit details are given in **fig. 4**.

results

After the rf feedback problem was licked, I enlisted the help of several local Amateurs in evaluating the synthesizer. All reported that the signal was spot-on frequency. The audio on transmit is as good using the synthesizer as when using crystal control. Received signals are also of similar quality. Measured frequency drift was ±50 Hz at the 12-MHz output between the ambient temperatures provided by a deep freeze and a mildly hot oven. Best of all, the project came in within the budgeted price, thanks partially to some keen scrounging.

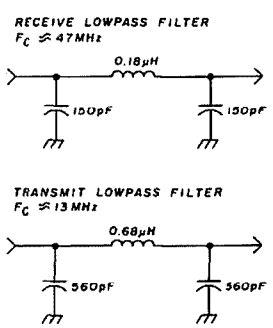


fig. 4. In-line lowpass filters prevent rf from re-entering the synthesizer through the interconnecting coax cables.

acknowledgments

I'd like to thank the authors mentioned previously for the ideas suggested in their articles. Also thanks to my friend Mike Blake, VE3HFP, for his comments and suggestions (and for having the patience to put up with me).

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ham radio



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CW anyone?

A challenge to break the world's code-speed record

Have you been telling your wife and kids what a hot-shot code operator you were back in the big war? Your wife was probably impressed, and your kids were spellbound each time you related your war stories. Or perhaps you wax nostalgic over your wireless days in that rusty old oil tanker? Wasn't that the vessel whose officers recruited high-speed operators from Joe's waterfront bar? Didn't you copy code eight hours a day at 50 words a minute from that coastal station? A most remarkable achievement — particularly since that Navy station never transmitted faster than 18 words per minute!

Perhaps you're a newcomer, just beginning to learn the code. If you have the ability to tune out these old timers, you should do very well indeed. They may tell you about the old-time wireless operator (or did he work for Western Union?) who waited on customers, made change, drank coffee, smoked a pipe, read the paper, and copied Morse code all at the same time. (For some strange reason the narrators can never remember the name of this operator of yesteryear.) The longer these old operators are away from Morse code, the faster they used to copy it.

a challenge

If you fit into any of the categories mentioned, or are new to Amateur Radio, then now is *the moment* of truth: now is the time to put your fist where your mouth is. I propose a threefold challenge:

1. The first is a *sanctioned code contest to* determine a national CW champion.

2. Next is a challenge to manufacturers of CW-oriented equipment to provide a suitable gift certificate to make the effort worthwhile.

3. Finally, I propose that *ham radio* magazine sponsor and perpetuate this contest on an annual basis, with a special award to anyone *officially exceeding the current world's record*. Quite a challenge. Are you game?

code-speed record

What about this record? According to the *Guinness Book of World Records*, "The highest recorded speed at which anyone has received Morse code is 75.2 words per minute, — over 17 symbols per second. This was achieved by Ted R. McElroy (W1JYN) in a tournament at Asheville, North Carolina, on July 2, 1939."

On that same day, Ted set another record. He copied the American Morse Code at a speed of 77 words per minute. Following the contest, Ted wrote a letter to his old instructor, Walt Candler, in which he complained that the transmitting apparatus would not go any faster, and that there wasn't any competi-

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tion. Ted wrote, "You can't have a contest unless there is competition."

When Ted first learned the code, he used a buzzer set and an ancient typewriter. Consequently, it took him nearly nine months to reach the modest speed of 50 words per minute. So what is the problem now? Why hasn't this record been broken? We're surrounded by electronic keyboards, buffered typewriters, and memory devices that Ted McElroy never dreamed of. Isn't it time to break this record? Perhaps this challenge will initiate a serious attempt to do so.

the competition

I know a number of operators who can copy Morse in excess of 75 words per minute. Just listen to Bill Eitel, W6UF, and the members of the Five-Star Net as they roar along at this speed. They can do it! Have you heard K7BW and his super speed contacts with N6AO? Watch Evelyn Headings, W7LLD, make a believer out of you as she copies at nearly 60 words per minute with a *pencil*. That's right — with a pencil. Can she break the world's record? Sure she can.

Jerry Ferrell, WB7VKI, has a certificate for 69.4 words per minute. Can he break the record? Well, he can as soon as he upgrades to General class and gets off the Novice bands. After that his code should begin to improve. However, he may be the first Novice to exceed 75 words per minute. There are many operators that can, and will, break this 42-year-old record. Why not this year?

getting started

If you're a beginner you might ask how to proceed. First, you should learn to type at 75 words per minute without error. Many operators copy in their heads and lose the ability to transcribe and produce "hard copy" of what they receive. In a sanctioned contest this is a must.

What about the code? That's the easy part. However, a word of advice. The first half hour of your initial exposure to code will determine your learning curve. You must develop correct practice habits. Here are some tips. Stay away from those who reside in self-pity as they struggle to attain 5 words per minute but never practice. Don't listen to the "experts" who passed 13 words per minute for just one minute, one time, down at the FCC office. You can do it! Just a little correct practice every day and you can be a winner. Enter that next club code contest and you're on your way.

contest rules

How about those club code contests? Have you ever listened to what is called code? The guy running the contest can't make a tape that runs over 20 words per minute, so he doubles the tape speed. Hey, don't do that, fella! It sounds like pure garbage. Give the guy who copies a chance!

What about official rules? For a world record to be valid, the contest must be held under rules similar to those in effect at the time Ted McElroy participated. According to those original rules, hard copy was submitted by each contestant. In the event of a tie, the text was checked for capitalization of each sentence and each proper noun. Text was selected, just before the contest, from old newspapers. Dates and common punctuation were permissible. Copy was machine-generated and transmitted. Dot-to-dash ratio was a one-to-three ratio with standard seven-element spacing between words. Contestants were allowed to bring their own typewriters and earphones. Three judges evaluated the contestants.

word count

What about word count? Our grandfathers counted four letters for each word. Many Amateurs now count five letters for each word. If the bit rate per letter in the alphabet is computed, it will be found that the average bit rate is just in excess of 11.3846 bits per letter. This amounts to 56.923 average bits per word, plus word space. For years the military used the word CODEX, which contains 56 bits of information, plus word space.

In 1922, a count was made of newspaper print, and it was found that the average five-letter word contained only 50 bits of information. The word PARIS contains 50 bits of information and is the timing word now used by the FCC. This later rate, plus word space, should be the standard count.

Addition of numbers and punctuation will change the average transmitted rate. That's right. Transmitted Morse will not be at a constant speed. Speed must be averaged. For this reason, the only acceptable count must be the total bits of information transmitted in a prescribed time frame. Determining the total number of bits transmitted and average speed per minute is a simple program for any computer.

Ever listen to the experts that stand around a hamfest code contest and comment, "That's not 30 words per minute. I can copy that in my head." They are probably the same people who are afraid to try the Extra class code examination. Perhaps all of their copy is in their head. Now is the time for them to put their ears where their mouth is.

Perhaps soon there will be sanctioned state, regional, and national code contests. Then it will be your chance! Practice a little every day beginning today, then participate in the next contest. I intend to participate. I intend to beat the world's record. How about you? Hope to see you there!

ham radio

tracking satellites in elliptical orbits

Computer program and sample problem for tracking OSCAR

The launch failure of the first AMSAT-OSCAR Phase III satellite was unfortunate but is only a temporary setback. The delay before the next launch will give many Amateurs a chance to get better prepared. This article contains information to enable an Amateur, with the aid of a computer or calculator, to track, in azimuth and elevation, a satellite in an elliptical orbit.

The altitude and velocity of a satellite in a circular orbit are nearly constant. However, both altitude and velocity are always changing during an elliptical orbit. Communication range is greatest at the apogee: the point of maximum altitude. This condition corresponds to the point of minimum velocity with respect to an observer on earth. A low velocity means low Doppler shift; it also means that the satellite will remain in view for a longer time and will not demand rapid antenna tracking.

The spot on the earth surface directly beneath the satellite is called the subsatellite point. A plot of the path of this point is the ground track and must include the effects of earth rotation. If the altitude and subsatellite point are known at a given time, the azimuth and elevation can be found using the same equations as for circular orbits.

Ground station latitude, δg, and longitude, λg, will be considered positive if the latitude is in the northern hemisphere and the longitude is west of the prime meridian. South latitude and east longitude must be entered as negative numbers.

sample program

A program for the HP-41C programmable calculator and printer was written to test the equations and to learn more about elliptic orbits. Table 1 shows the variable storage locations. Let's work through an example. Our ground station is located in Los Angeles with $\delta g = 34^{\circ}$ and $\lambda g = 118^{\circ}$. The orbital parameters are:

By Paul C. Bunnell, WA6VJR, 1053 Nordhal Road, San Marcos, California 92069

R02=	0.685
R03=	328
R10=	15
R11=	9
R12=	21.05
R14=	0.5592
R15=	0.8290
R16=	0.8387
R17=	118
R18=	210
R19=	3963.2
R20=	100
R21=	0.1768

table 1. Storage locations of problem variables.

R00 =	λ
R01 =	Re/Rs
R02 =	e
R03 =	Ps
R04 =	COSδs
R05 =	r or COSθ
R06 =	E or SINλgs
R07 =	δs or eCOSE−1
R08 =	Δt
R09 =	λs or SINθ
R10 =	TIME INCR.
R11 =	λref
R12 =	Tref
R13 =	SINδs
R14 =	SINδg
R15 =	COSδg
R16 =	SINi
R17 =	λg
R18 =	Ω
R19 =	Re
R20 =	ORBIT
R21 =	μ

table 2. Problem initial conditions.

GROUND TRACK

TIME	LAT	LONG	RNG
-315	-55.0	159.6	3.1
-300	-51.0	104.6	4.0
-285	-38.5	86.2	4.5
-270	-28.8	79.7	4.8
-255	-21.4	77.3	5.0
-240	-15.5	76.7	5.2
-225	-10.7	77.1	5.3
-210	-6.7	78.2	5.3
-195	-3.1	79.6	5.4
-180	0.0	81.3	5.4
-165	2.8	83.3	5.5
-150	5.4	85.4	5.5
-135	7.7	87.5	5.5
-120	10.0	89.8	5.6
-105	12.1	92.1	5.6
-90	14.1	94.5	5.6
-75	16.0	96.9	5.6
-60	17.8	99.4	5.6
-45	19.6	101.8	5.6
-30	21.4	104.2	5.6
-15	23.1	106.6	5.6
0	24.8	109.0	5.6
15	26.5	111.3	5.6
30	28.2	113.6	5.6
45	29.8	115.9	5.6
60	31.5	118.0	5.6
75	33.3	120.1	5.6
90	35.0	122.6	5.6
105	36.8	123.7	5.6
120	38.6	125.3	5.6
135	40.5	126.6	5.5
150	42.5	127.6	5.5
165	44.5	128.2	5.5
180	46.6	128.2	5.4
195	48.8	127.5	5.4
210	51.0	125.7	5.3
225	53.3	122.4	5.3
240	55.3	116.9	5.2
255	56.8	108.1	5.0
270	56.7	95.0	4.8
285	52.9	77.1	4.5
300	41.4	56.6	4.0
315	14.6	35.2	3.1

table 3. Printout of sample problem showing tracking parameters. Range is in thousands of statute miles.

reference orbit No.	100
time reference at apogee (*Tref*)	21.0500 (HH.MMSS)
longitude reference at apogee (λ*ref*)	9°
inclination (*i*)	57°
argument of perigee (Ω)	210°
eccentricity (*e*)	0.685
period of ½ orbit (P_s)	328 minutes

The radius of the earth, R_e, is 3963.2 statute miles, the normalized gravational constant, μ', is 0.176842228. We will choose time increments of 15 minutes. These initial conditions are stored as shown in **table 2**. If ground track information is desired, the program is started at label **E**. The calculator halts and prompts you for the number of the orbit you wish to investigate. Let's look at orbit 105. Enter that number and press the **R/S** key to resume program execution. In a few minutes **table 3** is printed. The apogee is at time 0, negative times *occur before* apogee, and the RNG (maximum range) column is in 1000s of statute miles. Also note that negative latitudes are in the southern hemisphere. To print the range with dimensions of kilometers or nautical miles, it's only necessary to enter R_e in those units.

The ground track can be plotted on a northern hemisphere polar map or just a piece of polar graph paper. I found it useful to use a transparent overlay, pivoted at the north pole. The ground track is marked on the overlay in grease pencil and may be rotated to any desired position. Maximum range information may be used to determine if the satellite is within range of any two ground stations.

Another part of the program calculates satellite azimuth and elevation. Only lines in which the satellite is above the horizon are printed. Start the program at label **ST** and again enter orbit 105. **Table 4** is the result, showing how azimuth and elevation change with time. The asterisk locates the time of apogee. It's not necessary to re-enter any of the orbital constants to plot other orbits. But, keep in mind that elliptic orbits suffer pertubations with time, and the latest orbital parameters available should be used.

The program requires one memory module and uses the 82143A peripheral printer. Data storage registers should be sized to 022. If a card reader is available, the program fits on two magnetic cards.

We're approaching a new era in Amateur satellite communications. New techniques and skills will be developed in the next few years as we gain experience. I hope this article will contribute to those efforts.

ORBIT 105

TIME	AZIMUTH	ELEVATION			
23:30	139	5	4:15	146	82
23:45	135	12	4:30	156	85
0:00	132	18	4:45	180	87
0:15	129	23	5:00	247	88
0:30	128	28	5:15	288	86
0:45	127	32	5:30	302	84
1:00	126	36	5:45	310	81
1:15	126	41	6:00	316	79
1:30	126	45	6:15	321	76
1:45	126	48	6:30	326	74
2:00	127	52	6:45	331	72
2:15	127	56	7:00	337	69
2:30	128	59	7:15	344	67
2:45	129	63	7:30	352	65
3:00	131	66	7:45	2	61
3:15	133	69	8:00	13	57
3:30	135	73	8:15	28	50
3:45*	137	76	8:30	44	36
4:00	141	79	8:45	62	11

table 4. Tracking dynamics showing satellite azimuth and elevation as functions of time.

bibliography

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appendix

The derivation of the equations is covered in the references, but there are several points of interest. **Fig. A1** is a view perpendicular to the plane of an elliptic orbit. The earth is at one focus, F, and the satellite at position S. Also shown are the apogee, A;perigee, P; one-half major axis, a; and one-half minor axis, b.

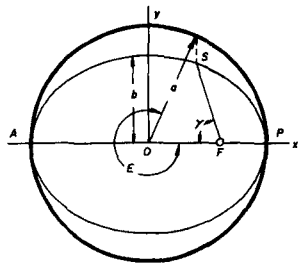


fig. 1. Geometry of the tracking problem for elliptical orbits.

A circle has been constructed with center, 0, bisecting AP, and with radius a. Angle E is identified as the elliptic anomaly, and Γ is the true anomaly. Both E and Γ are related to the mean anomaly, M (see eqs. **A1** and **A3**).

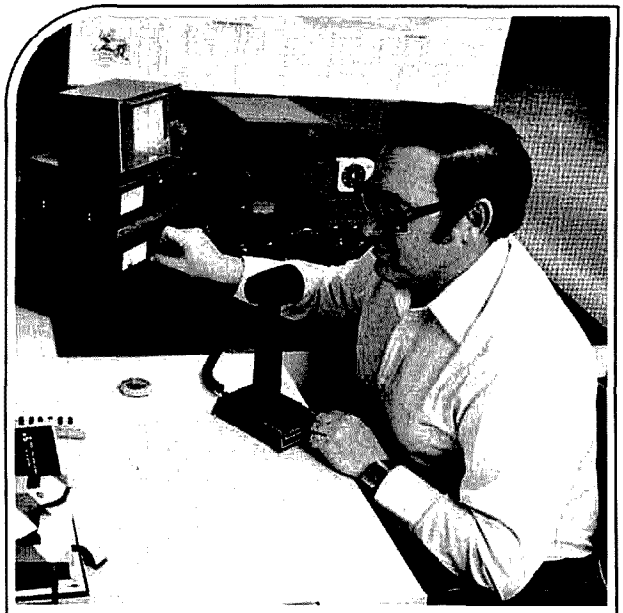
The problem to be solved (sometimes called the Kepler problem) is to find E, given Δt (the time of flight from S to A). With E known Γ can be found from eq. **A3**, and the satellite position with respect to the earth is then established.

We start the solution by approximating the value for E, calculating M', and generating an error term, ξ. E' is formed and checked in eq. **A2** to see if the error term has been reduced to zero. If not, return to eq. **A1**, substituting E' for E, and repeat the process. Only four or five iterations are necessary for an accuracy of 1 part in one million.

λ_0 is commonly called the longitude of the ascending node. It is derived from the argument of perigee, Ω. The location of the subsatellite point is given by latitude δs, and the longitude, λs. Rs is the instantaneous satellite distance from the center of the earth. The maximum range is an arc on the surface of the earth from the subsatellite point to a location where the satellite elevation drops to zero.

```
 01*LBL 'ST"
 02 XEQ 04
 03 STO 00
 04 CF 12
 05 "TIME  A
ZIMUTH"
 06 "⊢  ELEV
ATION"
 07 AVIEW
 08*LBL 05
 09 XEQ 01
 10 FIX 2
 11 60
 12 /
 13 RCL 12
 14 HR
 15 +
 16 RND
 17 FIX 0
 18 24
 19 MOD
 20 INT
 21 10
 22 X>Y?
 23 "⊢ "
 24 ARCL Y
 25 "⊢:"
 26 LASTX
 27 FRC
 28 60
 29 *
 30 X<Y?
 31 "⊢0"
 32 ARCL X
 33 RCL 08
 34 X=0?
 35 "⊢*"
 36 X≠0?
 37 "⊢ "
 38 RCL 13
 39 RCL 17
 40 RCL 09
 41 -
 42 SIN
 43 STO 06
 44 X<> L
 45 COS
 46 RCL 15
 47 *
 48 RCL 04
 49 *
 50 RCL 14
 51 RCL 13
 52 *
 53 +
 54 STO 05
 55 RCL 14
 56 *
 57 -
 58 RCL 15
 59 /
 60 RCL 05
 61 ACOS
 62 SIN
 63 STO 09
 64 /
 65 ACOS
 66 RCL 06
 67 SIGN
 68 *
 69 360
 70 MOD
 71 XEQ 08
 72 "⊢      "
 73 RCL 05
 74 RCL 01
 75 -
 76 RCL 09
 77 /
 78 ATAN
 79 XEQ 06
 80 GTO 05
 81*LBL E
 82 XEQ 04
 83 STO 00
 84 "GROUND
TRACK"
 85 AVIEW
 86 CF 12
 87 ADV
 88 "TIME
LAT"
 89 "⊢   LON
G   RNG"
 90 AVIEW
 91*LBL 03
 92 XEQ 01
 93 FIX 0
 94 XEQ 02
 95 FIX 1
 96 RCL 07
 97 XEQ 08
 98 RCL 09
 99 XEQ 08
100 RCL 01
101 ACOS
102 D-R
103 RCL 19
104 *
105 .1
106 %
107 XEQ 06
108 GTO 03
109*LBL 01
110 FIX 6
111 1
112 RCL 08
113 RCL 03
114 /
115 -
116 PI
117 *
118 STO 06
119 ENTER↑
120*LBL 00
121 CLX
122 RCL 06
123 R-D
124 RCL 02
125 P-R
126 1
127 -
128 STO 07
129 CLX
130 RCL 06
131 -
132 +
133 RND
134 RCL 07
135 /
136 ST- 06
137 X≠0?
138 GTO 00
139 RCL 06
140 R-D
141 COS
142 RCL 02
143 -
144 RCL 07
145 /
146 ACOS
147 RCL 08
148 SIGN
149 *
150 STO 05
151 RCL 18
152 +
153 XEQ 07
154 RCL 00
155 -
156 RCL 08
157 3.989
158 /
159 +
160 RCL 11
161 +
162 360
163 MOD
164 STO 09
165 1
166 RCL 02
167 RCL 05
168 COS
169 *
170 -
171 RCL 03
172 PI
173 /
174 2
175 ENTER↑
176 3
177 /
178 Y↑X
179 /
180 RCL 21
181 /
182 1
183 RCL 02
184 X↑2
185 -
186 /
187 STO 01
188 CLA
189 RCL 08
190 RTN
191*LBL 08
192 "⊢ "
193*LBL 02
194 RND
195 ENTER↑
196 ABS
197 X=Y?
198 "⊢ "
199 100
200 X>Y?
201 "⊢ "
202 SQRT
203 X>Y?
204 "⊢ "
205 ARCL Z
206 RTN
207*LBL 04
208 FIX 0
209 SF 12
210 CF 29
211 "ORBIT
212 PROMPT
213 ARCL X
214 AVIEW
215 ADV
216 ENTER↑
217 X<> 20
218 -
219 RCL 03
220 *
221 2
222 /
223 ENTER↑
224 X<> 11
225 +
226 360
227 MOD
228 X<> 11
229 15
230 /
231 RCL 12
232 HR
233 +
234 24
235 MOD
236 HMS
237 STO 12
238 RCL 03
239 RCL 10
240 MOD
241 RCL 03
242 -
243 STO 08
244 RCL 18
245*LBL 07
246 1
247 P-R
248 X<>Y
249 CHS
250 RCL 16
251 *
252 STO 13
253 ASIN
254 STO 07
255 COS
256 STO 04
257 /
258 ACOS
259 RCL 07
260 SIGN
261 *
262 RTN
263*LBL 06
264 XEQ 02
265 RCL Z
266 X>0?
267 AVIEW
268 RCL 08
269 RCL 10
270 +
271 STO 08
272 RCL 03
273 X<Y?
274 STOP
275 .END.
```

Program listing for the Hewlett-Packard HP-41C programmable calculator.



fact: armchair copy begins here

ask:

KA2CLF	WB5VOB	WD8MQJ
W21SB	W71JH	KB9NR
W31TG	W7KHD	W9BB
K4CX4	N8AQW	WB9VCI
K4HCD	K8ZYK	N9MP
N4CVV	K8ZZO	N9BHT
K5RDP	KB8GD	WØJO
W5UKS	WB8SHV	4X4AN/W9

If you've been "reading the mail" on recent transmissions from the hams listed above, you've heard the kind of solid copy that rates a Q5. One reason is that they've recently switched to Shure's new 444D SSB/FM Base Station Microphone. We've been getting glowing reports on the 444D's switch-selectable dual impedance feature which makes for compatibility and changeability from rig to rig; improved million-cycle PTT control bar (with vox/normal switch and continuous-on capability); and its comprehensive all-new wiring guide. The cable leads are arranged to permit immediate hook-up to transmitters with either isolated or grounded switching. Ask the hams who own one!

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additional definitions:

Ps = period of ½ orbit
e = eccentricity
i = inclination
Ω = argument of perigee
λref = longitude reference at apogee
Re = radius of earth
Rs = distance from earth center to satellite
μ' = normalized gravitational constant
δg = ground station latitude
λg = ground station longitude

$$\text{Let } M = \pi\left(1 - \frac{\Delta t}{Ps}\right) \text{ in radians}$$

$$\text{Guess } E = M$$

$$M' = e \sin\left(\frac{360E}{2\pi}\right) - E \qquad \text{(A1)}$$

$$\xi = \frac{M' - M}{e \cos E - 1} \qquad \text{LOOP}$$

$$E' = E - \xi$$

$$\text{If } E' \neq E \text{ (return to A1)} \qquad \text{(A2)}$$

$$\Gamma = SIGN(\Delta t) \cos^{-1}\left(\frac{\cos E - e}{e \cos E - 1}\right) \qquad \text{(A3)}$$

$$\delta o = \sin^{-1}(-\sin \Omega \sin i)$$

$$\lambda o = SIGN(\delta o) \cos^{-1}\left(\frac{\cos\Omega}{\cos\delta o}\right)$$

$$\delta s = \sin^{-1}(-\sin(\Omega + \Gamma)\sin i)$$

$$\lambda s = SIGN(\delta s) \cos^{-1}\left(\frac{\cos(\Omega + \Gamma)}{\cos \delta s}\right) + \frac{\Delta t}{3.989} - \lambda o + \lambda ref$$

$$\frac{Rs}{Re} = \frac{\mu'(1 - e^2)(Ps/\pi)^{2/3}}{1 - e \cos \Gamma}$$

$$\text{maximum range} = \frac{Re}{1000} \frac{2\pi}{360}\left[\cos^{-1}\left(\frac{Re}{Rs}\right)\right]$$

$$\theta = \cos^{-1}[\sin \delta s \sin \delta g + \cos \delta s \cos \delta g \cos(\lambda s - \lambda g)]$$

$$\text{azimuth} = \cos^{-1}\left(\frac{\sin \delta s - \cos \theta \sin \delta g}{\cos \delta g \sin \theta}\right)$$

$$\text{if } \sin(\lambda s - \lambda g) < 0, \text{ azimuth} = 360 - \text{azimuth}$$

$$\text{elevation} = \tan^{-1}\left(\frac{\cos \theta - Re/Rs}{\sin \theta}\right)$$

Note: $SIGN(x) = -1$ if x is negative
$+1$ if x is positive or zero

ham radio

protection for your solid-state devices

Fail-safe regulator for bench supply reduces mortality rate

Many Amateur experimenters have learned from experience that active solid-state devices are not as forgiving as vacuum tubes. A 6L6 for example can absorb considerable abuse and keep right on working; long ago we discovered we could avoid a catastrophic failure by quickly switching off the power supply when the plate began to glow.

Unfortunately, solid-state devices don't provide us with that opportunity. High-performance devices such as vhf or microwave transistors react quickly and violently when overloaded; the time required for a GASFET to destroy itself is considerably less than a microsecond. In view of the relatively high cost (and consequent scarcity) of these devices, it seems appropriate to attack the problem at the source — the power source.

Accidents can and do happen. Consider a typical 0-30 volt bench power supply adjusted to 10 volts output, connected to a transistor circuit for test. If the supply includes a large capacitor across its output terminals, it is a potential transistor killer. In the event we should inadvertently increase the output voltage (perhaps by bumping the knob), even though the power supply's current limiting mechanism should react properly to the ensuing overcurrent condition, the energy already stored in the output capacitor can create a transient that may destroy the transistor.

built-in protection

If a circuit employing a bipolar transistor is to be tested at known, fixed voltage and current, protection can be built in. The single-stage transistor amplifier shown in **fig. 1** is a typical example. An amplifier of this kind is essentially damage proof.

general-purpose regulator

A general-purpose bench power supply regulator is illustrated in **fig. 2**. This regulator is particularly useful when testing power amplifiers. It includes provisions for setting the maximum available voltage and current levels to desired safe values. In the circuit shown, the 12-volt zener at the output is used as backup for the MOSFET shunt regulator. If the regulator should fail, the zener would limit the output to 12 volts.

R1 sets the maximum available load power, which in this case is 1.011 watts:

$$P_o(max) = \frac{(E_{in})^2}{4R1}$$

where $E_{in} = 18.7$ (manufacturer's tolerance)
$R1 = 91\text{-}5\ percent$ (tolerance)

$$P_o(max) = \frac{(18.7)^2}{4(86.45)} = 1.011\ watts$$

Note that this maximum power condition provides 98.9 milliamperes and 9.0 volts. Any increase in load

By Henry H. Cross, W1OOP, 111 Birds Hill Avenue, Needham, Massachusetts 02192

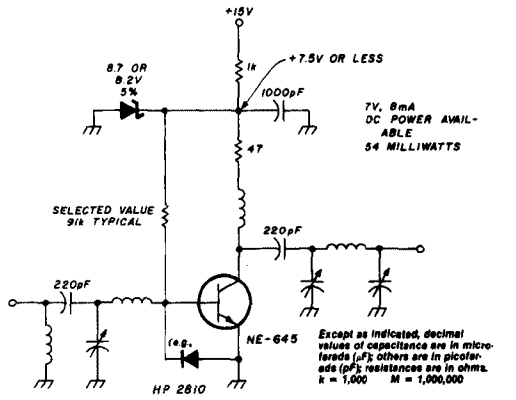


fig. 1. An amplifier with built-in protection.

current beyond this point will take the shunt regulator off-line, and the output voltage (and load power) will drop, as shown in fig. 3. The maximum current the regulator can supply is 198 milliamperes.

To provide flexibility, the bench regulator should include provisions for changing R1. I suggest that the control be located where it normally would be inaccessible; this is insurance against accidentally changing its value. In any event, avoid making R1 a front-panel control knob.

You can adjust the transient response of the shunt regulator for minimum overshoot by selecting specific values for C1 and R3. Use a telegraph key as a momentary shorting device while observing the output voltage on a high-speed oscilloscope. I used a combination of 180 ohms and a 0.01-μF capacitor for proper damping, but other supplies may require different values. Also check the transient response when the power supply is turned on and off. R8 and C3 provide high-frequency feedback for stability.

The bench power supply regulator also includes an adjustable 5-volt negative supply. A 741 op amp is included to provide good regulation; only a limited current capacity is needed. Gate bias should reduce (become less negative) in response to clockwise rotation of the control. V_D should increase with clockwise control rotation. In either case, *current* in-

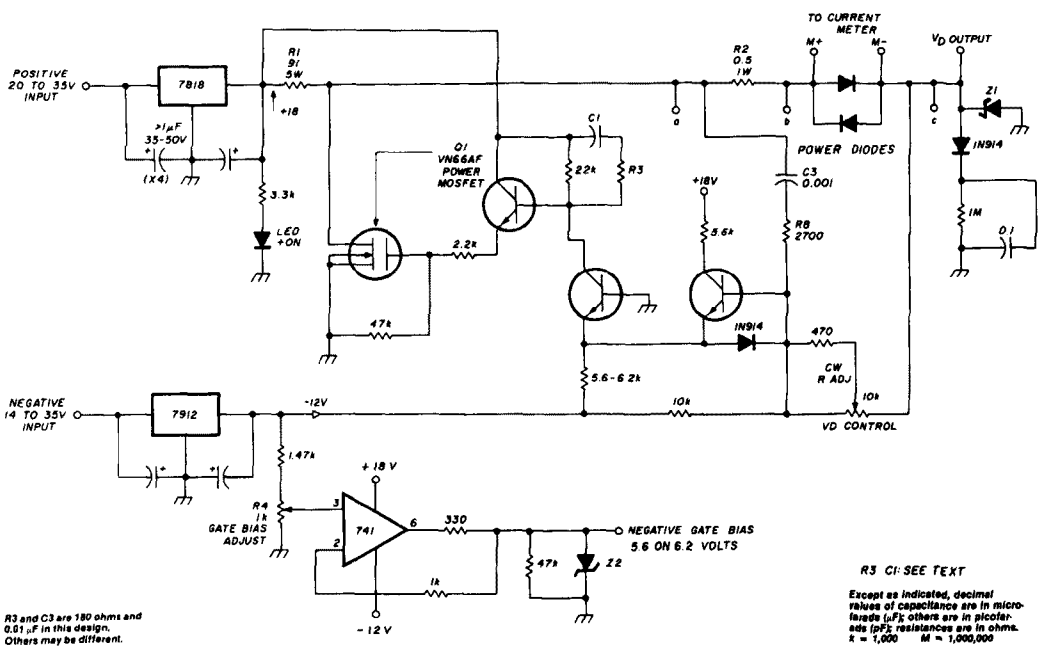


fig. 2. Basic essentials of a bench supply regulator.

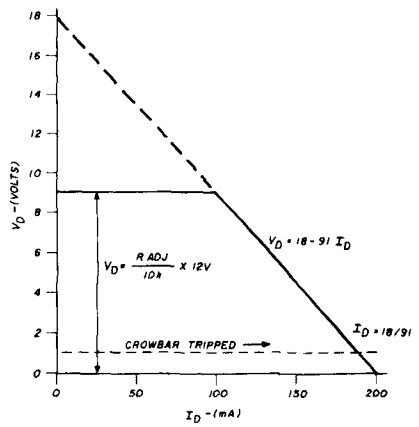


fig. 3. Performance of the general-purpose bench power-supply regulator. Maximum power condition is 98.9 milliamperes at 9 volts.

creases with clockwise rotation. With some additional effort, you may be able to adjust the control-circuit parameter values so that the output voltage and current match the dial readings.

low-voltage regulators

Lower power GASFETS generally require 5-50 milliamperes at approximately 3 volts. It would be desirable to use a 4-volt zener at the output in this case as backup for the shunt regulator; however, since zeners in this voltage range don't exhibit the sharp knees of higher voltage types, the regulator is in need of some other kind of protective device.

Fig. 4 illustrates a *crowbar* circuit that can solve this problem. The circuit consists of a shunt SCR that fires when the regulator output voltage exceeds a preset value. The drop across the forward-conducting SCR is about 0.8 volt, not small enough to turn the supply completely off, but low enough to provide a good measure of protection.

An LM339 comparator functions as an open-loop op amp. R6 is adjusted so that the output will go low if the regulator output exceeds 3.1 volts. When this happens, the trigger voltage goes high, firing the SCR. Note that the anode sustaining current is about

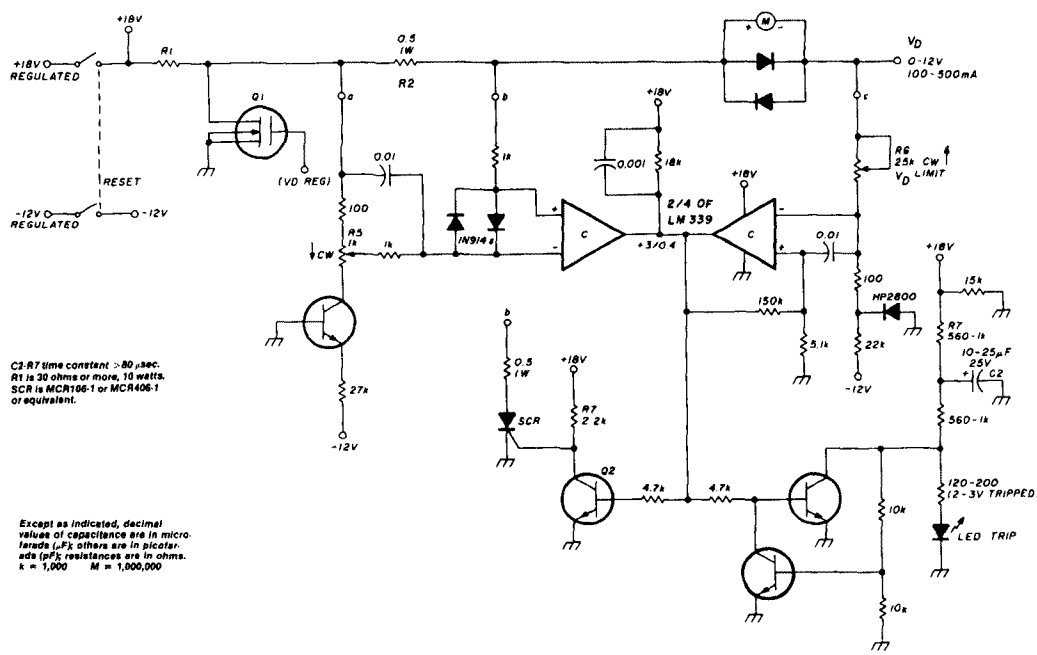
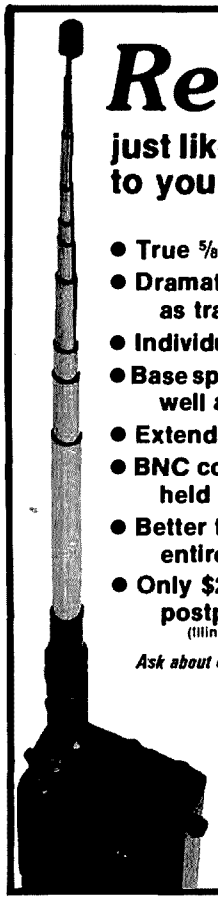


fig. 4. Crowbar circuit for low-voltage regulators.



Reach Out!

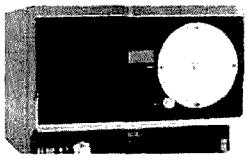
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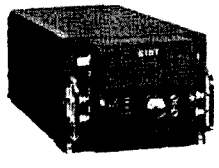
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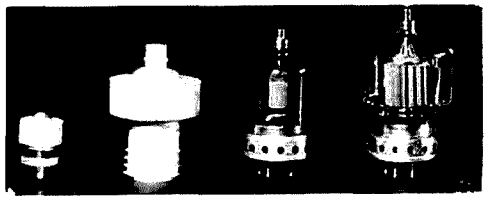
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5 milliamperes, and it might be less than what the FET is drawing; so we have to keep triggering it. Normally the current through R6 is pulled to ground through the associated forward conducting transistor Q2.

Another comparator compares the voltage across current-sensing resistor R2 against a bucking voltage. When the preset current limit is exceeded, the SCR triggers. R5 is the current-limit control.

Both comparators are operated from a single power supply, with the GND terminals grounded. Under this condition, operation may become erratic if any of the op amp inputs go below ground by more than 0.5 volt. To avoid a possible problem here, the HP2800 diode and 510-ohm resistor should be included as shown.

The current meters are located across terminals b-c, after the crowbar (for obvious reasons). If the crowbar circuit should fire, the output voltage will drop to some value less than 1 volt, and the current will fall to a low value. To reset the regulator, turn off both power supplies, wait one second or longer, and turn them back on again. Note that the order in which the supplies are turned on or off is unimportant because, if the negative voltage is lacking, the positive voltage will not come on.

If a double-pole, single-throw toggle switch were connected between the regulated input voltages and the regulator, it would function as a RESET control. This is indicated at the left in **fig. 4**. The reset switches are normally closed.

The circuits of **figs. 2** and **4** also include LEDs, which indicate that each power supply is ON. Another LED indicates that the overcurrent circuit has tripped. When not otherwise indicated, the transistors are 2N3904 or 2N2222s. The comparators are LM339, 393, 2901, or 2903s.

summary

Power supplies used for experimental purposes should be equipped with fail-safe regulators, including:

1. Reverse voltage protection
2. Overvoltage protection
3. Thermal runaway protection
4. Limited available power

Regulators should be equipped with limit controls on output voltage and current. (Limit controls should not be confused with adjustments.) Shunt-type regulators can be power limited and stable without requiring a large energy-storing, transistor-killing capacitor across the output terminals. Simple electronic biasing circuits are generally best.

ham radio

Questions and Answers

Entries must be by letter or post card *only. No telephone requests will be accepted. All entries will be acknowledged when received. Those judged to be most informative to the most Amateurs will be published. Questions must relate to Amateur Radio.*

Readers are invited to send a card with the question they feel is most useful that appears in each issue. Each month's winner will receive a prize. We will give a prize for the most popular question of the year. In the case of two or more questions on the same subject, the one arriving the earliest will be used.

congratulations to...

WD5GMF, for his question about decibels (dB) in the September, 1980, issue of *Ham Radio Horizons*. Several readers commented on the usefulness of that question and the answer given. The subject of dB has mystified thousands of Amateurs and still shows up in discussions of electronics theory and in an exam question now and then. Thanks to WD5GMF for asking the question and thanks to those of you who took the time to comment.

narrow-band voice modulation

Please explain the narrow-band voice modulation system now being used by some Amateurs. Paul Drunen, ***KA4CMZ.***

This modulation system is being tried in both Amateur and commercial radio circles, with the expectation that it will allow more signals per band, or permit closer spacing of channelized communications such as vhf business, police, and aircraft. The principle of operation is to carefully shape the audio from the microphone by slicing it into essential segments, then processing those segments before they reach the modulator.

There are several natural gaps in speech; some of these gaps are essential and some are not. One non-essential gap occurs between approximately 600 and 1,000 Hz. Speech sounds below 600 Hz are essential and preserved. Sounds above approximately 1,500 Hz up to 2,500 or 3,000, are essential and are likewise preserved. There are small gaps in this high range, and they, too, are essential for the understanding of speech, thus are preserved along with the sounds.

The sounds below 600 Hz are transmitted as is, but those in the upper band of 1,500-2,500 Hz are inverted and shifted lower in frequency, then combined with the low (250-600 Hz) audio, and fed to the modulator. This process not only closes the non-essential gap just above 600 Hz, but also reduces the *total* width of the audio signal to something like 250-1,600 Hz (there is an optional system that provides up to 2,100-Hz width if desired).

Additionally, the audio signal is processed for more nearly constant amplitude in the transmitter (compressed), and then expanded in the receiver, in a process *called* compandoring.

The modified audio must be fed through a special circuit in the receiver to eliminate the processing, which restores the proper gap and turns the audio "right-side-up."

At this time, the system uses several specialized ICs in the transmitter and receiver. It is undergoing many tests and evaluations of effectiveness for Amateur and commercial use.

recommended reading

Harris, R.W., and Gorski, J.C., "A New Era Voice Communications," *QST*, December, 1977. Harris, R.W., and Cleveland, J.F., "A *Baseband* Communications System," *QST*, November, 1978 (part 1), and December, 1978 (part 2). Also, *The Radio Amateur's Handbook*, 57th edition, 1980, ARRL, Newington, Connecticut 06111, Chapter 14.

USB, LSB, or DSB?

Would you please explain the difference between USB, LSB, and Double Sideband. Stephen Serio.

Fig. 1 will help you understand these three modes of voice communication, and how they got that way. At **A**, you see an ordinary amplitude-modulated carrier, abbreviated a-m. It is a natural outcome of the process of modulating an rf signal with a voice signal. It is made up of a carrier and two sidebands, one above and one below the carrier.

If the modulation takes place in a *balanced modulator*, the carrier is balanced out (nulled), and the result is two sidebands with no carrier, **B**.

The next step is to filter out the unwanted sideband by a mechanical or crystal filter that passes only the sideband you want, **C**. To obtain the other sideband, you could use another filter to pass that one and reject the unwanted one. However, that's too expensive.

A simpler, and less-expensive way, is to change the frequency of the crystal that supplied the carrier for the modulator in the first place. Thus you simply shift the unwanted sideband to the other side of the filter's window, as shown at D.

To properly receive SSB, you only have to duplicate the frequency of the carrier oscillator, and place it on the correct side of the sideband you want to hear, which will duplicate the original a-m signal minus one sideband.

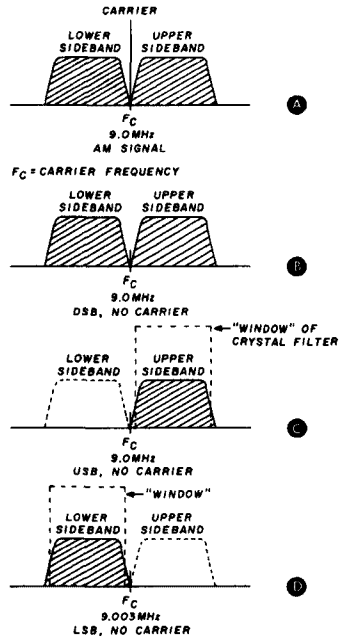


fig. 1. The derivation of DSB, LSB, and USB from an amplitude-modulated signal. Note that to obtain lower sideband, the carrier is moved to keep the desired sideband in the "window" of the filter, rather than use a separate filter, which would be very expensive. The frequencies shown are for illustration purposes only — SSB can be generated at any frequency and then heterodyned to the ham band of your choice.

final protection

I've used an SWR meter with various antenna tuners, and have managed to load up many types of antennas, such as random lengths of wire, zipcord, window screens, and fences. Results have often been surprisingly good. Can I be confident that a load somewhere near 50 ohms is presented to my transmitter, when it works okay, and the SWR reads below 2:1? I don't want to damage the final stage on my Argonaut. John F. Leahy, ***WB6CKN.***

The only time you can be reasonably sure that your transmitter is working into 50 ohms is when the reading on your SWR meter is 1:1. At any reading higher than this, the impedance at the transmitter is something else. The reading might be 1.5:1, 1.8:1, or 2:1 at the SWR meter, but what is it at the end of the piece of coax that connects to the transmitter? The apparent SWR changes with the length of the coax, and can be something entirely different a few feet down the line from the meter. Try setting up your tuner for a 2:1 reading on 10 meters. Don't touch any tuning controls, and add a 5-foot (1.5-meter) piece of coax between the tuner and the SWR meter. It will probably read something other than 2:1.

As to how your transmitter likes this sort of treatment, if it puts out reasonable power without overheating, there's no problem. Ten-Tec says that the output transistors are rugged enough to withstand an open or short circuit (but, of course, long-term operation with a very high SWR is not recommended), thus an SWR of 2:1 doesn't present any real danger.

velocity factor

What is velocity factor? I've seen it in various antenna articles but haven't yet found a good definition. Richard Anderson.

Velocity factor is a property of transmission lines that must be taken into account when calculating the physical length of a tuned line or a matching transformer made from the line. The velocity of a radio wave traveling down the line is less than in free space. It varies from about 0.65 for polyethylene-dielectric coaxial cables to 0.975 for open-wire (air dielectric) transmission lines.

efficiency

I've read about antenna tuners and Transmatches in several publications, but nothing is mentioned about their efficiency. I've noticed that most gear is listed at 50-70 per cent efficiency, so can I assume that with 100 watts dc input into a Transmatch that I'll get 50 to 75 watts output? S. Capasso, ***KA1ETB.***

First of all, you don't run dc input to a Transmatch or antenna tuner. Dc input numbers refer only to amplifiers or the final stage of a transmitter. A good linear amplifier, as used for SSB, would work at 40 to 60 per cent efficiency, and a class-C amplifier (for CW or fm) can sometimes get up to 70 per cent.

However, the efficiency of a passive device such as an antenna tuner is determined by the losses of the wire in its coils and the material in the toroid (if any). A good antenna tuner with air-wound coils will have very little loss — 5 per cent or less. Using a toroidal balun transformer can introduce more losses, depending on the material used and the frequency of operation, anywhere from 10 to 40 per cent. Sometimes you have to accept these losses to use an unconventional antenna, or to use one antenna on more than one band. It's better if you can design your antenna for an input impedance of 50 ohms, and do without the antenna tuner, if at all possible.

ham radio

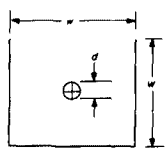
transmission-line circuit design

Using distributed resonant circuits for VHF/UHF transmission lines

This is part **4** of a 5-part article dealing with the *design of resonant* transmission lines. In part 1, which appeared in *ham radio* for November, 1980, I presented the governing expressions for calculating the parameters for twelve transmission-line configurations. Programs were given using the HP-97 printer capability.

Parts **2** and **3** discussed the geometry and presented the calculator programs for solving the equations for eight of the twelve line configurations: coaxial lines; parallel plates; parallel wires in air; single wire over a plane (*ham radio*, January, **1981**); circular wire between planes; parallel wires over a plane; circular wire in an open trough; parallel wires between planes/rectangular box (*ham radio*, February, 1981).

In this part of the article, the last four of the twelve line configurations are examined: circular wire in a square shield; stripline over a plane; stripline centered between parallel planes; and the helical resonator. Part 5 will provide a summary of what has been discussed and show a design example for a 2-meter amplifier.



circular wire in a square shield

This is not a usual configuration encountered or designed, because the square cavity configuration imposes complexities due to its geometry. However, it is often chosen in the design of production filters and diplexers because dip-braze techniques can be readily used, mitigating other difficulties. The formulation yielding Z_0 (reference 5) is:

$$Z_0 = \frac{59.96}{\sqrt{\epsilon_r}} \ln\left(1.0787\,\frac{w}{d}\right) \qquad (41)$$

where Z_0 = transmission-line impedance (ohms)
ϵ_r = dielectric constant
w = width of each side
d = diameter of center conductor

Fig. **18** shows Z_0 versus w/d for common values. Table **35** is the HP-67/97 program for calculating the unknown from the known variables. Table **36** identifies the storage registers used. Table **37** shows how the program is controlled.

table 35. HP-67/97 program for calculating Z_0 and w/d for a wire in a square shield:

step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code
001	*LBLA	21 11	036	STO5	35 05
002	STO0	35 00	037	5	05
003	√x	54	038	9	09
004	STO1	35 01	039	.	−62
005	RTN	24	040	9	09
006	*LBLB	21 12	041	6	06
007	STO2	35 02	042	÷	−24
008	R↓	−31	043	RCL1	36 01
009	STO3	35 03	044	X=0?	16-43
010	RCL2	36 02	045	GSB8	23 08
011	÷	−24	046	x	−35
012	STO4	35 04	047	e^x	33
013	*LBL1	21 01	048	1	01
014	1	01	049	.	−62
015	.	−62	050	0	00
016	0	00	051	7	07
017	7	07	052	8	08
018	8	08	053	7	07
019	7	07	054	÷	−24
020	x	−35	055	STO4	35 04
021	LN	32	056	R/S	51
022	5	05	057	*LBLD	21 14
023	9	09	058	STO4	35 04
024	.	−62	059	GTO1	22 01
025	9	09	060	*LBL9	21 09
026	6	06	061	1	01
027	x	−35	062	STO1	35 01
028	STO6	35 06	063	RCL6	36 06
029	RCL1	36 01	064	RCL1	36 01
030	X=0?	16-43	065	RTN	24
031	GSB9	23 09	066	*LBL8	21 08
032	÷	−24	067	1	01
033	STO5	35 05	068	STO1	35 01
034	R/S	51	069	RTN	24
035	*LBLC	21 13	070	R/S	51

By H.M. Meyer, Jr., W6GGV, 29330 Whitley Collins Drive, Rancho Palos Verdes, California 90274

table 36. Register contents for HP-67/97 program for calculating Z_0 and w/d for a wire in a square shield.

STO 0	ϵ_r
STO 1	$\sqrt{\epsilon_r}$
STO 2	d
STO 3	w
STO 4	w/d
STO 5	Z_0
STO 6	INTERIM

table 37. HP-67/97 program control for calculating Z_0 and w/d for a wire in a square shield:

calculates	$\sqrt{\epsilon_r}$	
enter	ϵ_r	press A
calculates	Z_0	
enter	w	press ENTER
enter	d	press B
calculates	w/d	
enter	Z_0	press C
calculates	Z_0	
enter	w/d	press D

Note: If no value for ϵ_r is entered, program assumes $\epsilon_r = 1 = air$.

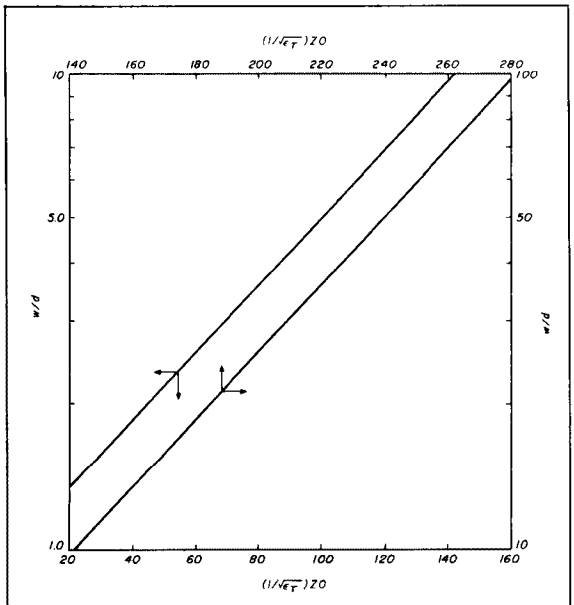
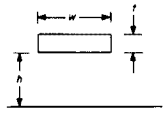


fig. 18. Z_0 versus w/d for a circular wire in a square shield.

stripline over a plane



This is perhaps one of the more useful transmission line configurations presently in use. Its applications are primarily stimulated by solid-state technology and the subsequent extensive use of microwave integrated circuits. One original formulation by S.B. Cohn (reference 6) was subsequently followed by M.V. Schneider (reference 7). The most accurate formulation known is by H.A. Wheeler (reference 3), and that is used here.

Table 38 identifies the method for calculating strip width, w, with h, t, Z_0, and ϵ_r known. The formulations from reference 3 are:*

$$\frac{w'}{h} = 8\sqrt{\frac{\left[e\,exp\left(\frac{Z_0}{42.4}\sqrt{\epsilon_r+1}\right)-1\right]\left[\frac{7+4/\epsilon_r}{11}+\frac{1+1/\epsilon_r}{0.81}\right]}{\left[e\,exp\left(\frac{Z_0}{42.4}\sqrt{\epsilon_r+1}\right)-1\right]}} \quad (42)$$

$$\frac{\Delta w}{t} = \frac{1}{\pi}\ell n\frac{4e}{\sqrt{\left(\frac{t}{h}\right)^2+\left(\frac{1/\pi}{w'/t-0.26}\right)^2}} \quad (43)$$

$$\Delta w' = \frac{1+1/\epsilon_r}{2}\Delta w \quad (44)$$

$$w = w' - \Delta w' \quad (45)$$

For the calculation of line Z_0 the method in table 39 is used. The formulations from reference 3 are:

$$\frac{\Delta w}{t} = \frac{1}{\pi}\ell n\frac{4e}{\sqrt{\left(\frac{t}{h}\right)^2+\left(\frac{1/\pi}{w/t+1.10}\right)^2}} \quad (46)$$

$$\Delta w' = \frac{1+1/\epsilon_r\Delta w}{2} \quad (47)$$

$$w' = w+\Delta w' \quad (48)$$

$$Z_0 = \frac{42.4}{\sqrt{\epsilon_r+1}}\ell n\left\{1+\left(\frac{4h}{w'}\right)\left[\left(\frac{14+8/\epsilon_r}{11}\right)\left(\frac{4h}{w'}\right)+\sqrt{\left(\frac{14+8\epsilon_r}{11}\right)^2\left(\frac{4h}{w'}\right)^2+\left(\frac{1+1/\epsilon_r\pi}{2}\right)^2}\right]\right\} \quad (49)$$

table 38. Method of calculating strip width:

1. Specify h, t, Z_0, and ϵ_r (from **fig. 1K**).
2. Determine w/h (from **eq. 42** — yields w').
3. Determine Δw (from **eq. 43**).
4. Determine $\Delta w'$ (from **eq. 44**).
5. Determine w (from **eq. 45**).

table 39. Method of calculating line Z_0:

1. Specify h, t, ϵ_r, and w.
2. Determine Δw (from **eq. 46**).
3. Determine $\Delta w'$ (from **eq. 47**).
4. Determine w' (from **eq. 48**).
5. Determine Z_0 (from **eq. 49**).

*The expression in parentheses following *exp* indicates the power to which *e* is raised.

table 40. HP-67/97 program for calculating ω and Z_0 for a striplina over a plana:

step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code
001	*LBLA	21 11	056	STO9	35 09	111	*LBL2	21 02	166	1	01
002	STO0	35 00	057	RCL1	36 01	112	RCL4	36 04	167	4	04
003	RTN	24	058	1/X	52	113	RCL3	36 03	168	+	− 55
004	*LBLB	21 12	059	1	01	114	÷	− 24	169	1	01
005	STO1	35 01	060	+	− 55	115	1	01	170	1	01
006	RTN	24	061	.	− 62	116	.	− 62	171	÷	− 24
007	*LBLC	21 13	062	8	08	117	1	01	172	X^2	53
008	STO2	35 02	063	1	01	118	+	− 55	173	RCL8	36 08
009	RTN	24	064	÷	− 24	119	Pi	16-24	174	4	04
010	*LBLD	21 14	065	RCL8	36 08	120	x	− 35	175	x	− 35
011	STO3	35 03	066	+	− 55	121	1/X	52	176	X^2	53
012	RTN	24	067	$\sqrt{X}$	54	122	X^2	53	177	x	− 35
013	*LBLE	21 15	068	RCL7	36 07	123	STO7	35 07	178	RCL7	36 07
014	STO4	35 04	069	÷	− 24	124	RCL3	36 03	179	+	− 55
015	RTN	24	070	8	09	125	RCL2	36 02	180	$\sqrt{X}$	54
016	*LBLa	21 16 11	071	x	− 35	126	÷	− 24	181	STO7	35 07
017	STOI	35 46	072	STO6	35 06	127	X^2	53	182	8	08
018	GSB;	23 45	073	RCL2	36 02	128	RCL7	36 07	183	RCL1	36 01
019	*LBL9	21 09	074	x	− 35	129	+	− 55	184	÷	− 24
020	RCL1	36 01	075	STOC	35 13	130	$\sqrt{X}$	54	185	1	01
021	1/X	52	076	RCL3	36 03	131	1/X	52	186	4	04
022	1	01	077	÷	− 24	132	1	01	187	+	− 55
023	+	− 55	078	.	− 62	133	e^x	33	188	1	01
024	2	02	079	2	02	134	x	− 35	189	1	01
025	÷	− 24	080	6	06	135	4	04	190	÷	− 24
026	RCL5	36 05	081	−	− 45	136	x	− 35	191	RCL8	36 08
027	x	− 35	082	Pi	16-24	137	LN	32	192	4	04
028	STOA	35 11	083	x	− 35	138	Pi	16-24	193	x	− 35
029	RTN	24	084	1/X	52	139	1/X	52	194	x	− 35
030	*LBL1	21 01	085	X^2	53	140	x	− 35	195	RCL7	36 07
031	RCL1	36 01	086	RCL3	36 03	141	STOB	35 12	196	+	− 55
032	1	01	087	RCL2	36 02	142	RCL3	36 03	197	RCL8	36 08
033	+	− 55	088	÷	− 24	143	x	− 35	198	4	04
034	$\sqrt{X}$	54	089	X^2	53	144	STO5	35 05	199	x	− 35
035	RCL0	36 00	090	+	− 55	145	GSB9	23 09	200	x	− 35
036	x	− 35	091	$\sqrt{X}$	54	146	RCL4	36 04	201	1	01
037	4	04	092	1/X	52	147	+	− 55	202	+	− 55
038	2	02	093	4	04	148	STOC	35 13	203	LN	32
039	.	− 62	094	x	− 35	149	RCL1	36 01	204	STO7	35 07
040	4	04	095	1	01	150	1/X	52	205	RCL1	36 01
041	÷	− 24	096	e^x	33	151	1	01	206	1	01
042	e^x	33	097	x	− 35	152	+	− 55	207	+	− 55
043	1	01	098	LN	32	153	2	02	208	$\sqrt{X}$	54
044	−	− 45	099	Pi	16-24	154	÷	− 24	209	1/X	52
045	STO7	35 07	100	÷	− 24	155	Pi	16-24	210	4	04
046	4	04	101	STO9	35 09	156	X^2	53	211	2	02
047	RCL1	36 01	102	RCL3	36 03	157	x	− 35	212	.	− 62
048	÷	− 24	103	x	− 35	158	STO7	35 07	213	4	04
049	7	07	104	STO5	35 05	159	RCL2	36 02	214	x	− 35
050	+	− 55	105	GSB9	23 09	160	RCLC	36 13	215	RCL7	36 07
051	1	01	106	CHS	− 22	161	÷	− 24	216	x	− 35
052	1	01	107	RCLC	36 13	162	STO8	35 08	217	STO0	35 00
053	÷	− 24	108	+	− 55	163	8	08	218	R / b s	51
054	RCL7	36 07	109	STO4	35 04	164	RCL1	36 01			
055	x	− 35	110	R/S	51	165	÷	− 24			

Table 40 is the HP-67/97 program used to calculate Z_0 and w. **Table 41** identifies the storage registers used, and **table 42** describes how the program is controlled.

A sample problem might readily explain how the program is used. Enter line Z_0, 50 ohms; dielectric constant, ϵ_r, 2.5; height, h, 1.0 mm; and thickness, t, 0.1 mm. Calculate the stripline width as indicated in **table 42**, $w = 2.7038\ mm$. Using this value for w, calculate Z_0 from the same parameters, $Z_0 = 49.9974$ *ohms*, which is in good agreement with the originally specified 50 ohms.*

table 41. Register contents for HP-67/97 program for calculating w and Z_0 for a stripline over a plane:

STO 0	Z_0	STO 7	INTERIM
STO 1	k	STO 8	INTERIM
STO 2	h	STO 9	$\Delta w/h$
STO 3	t	STO A	$\Delta w'$
STO 4	w	STO B	$\Delta w/t$
STO 5	Δw	STO C	w'
STO 6	w'/h	STO D	h/w'

table 42. HP-67/97 program control for calculating w and Z_0 for a stripline over a plane:

enter Z_0	press A
enter ϵ_r	press B
enter h	press C
enter t	press D
enter w	press E

Enter any four of the above; select one of the following parameters:

$1 - w$
$2 - Z_0$

and press fa.

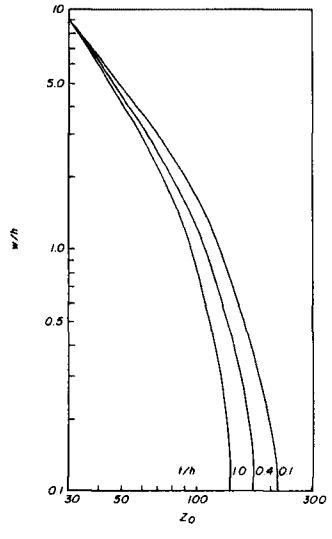


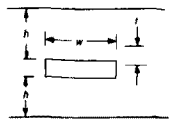
fig. 19. Z_0 versus w/h for selected values of t/h for a stripline over a plana, $\epsilon_r = 1$.

table 43. Values of Z_0 for w/h versus t/h for various values of ϵ_r for a stripline over a plane:

w/h	t/h 0.1	0.2	0.4	1.0
		$\epsilon_r = 1.0$		
0.1	212.83	190.9	166.47	135.65
0.4	161.66	151.47	138.21	118.19
0.8	137.49	123.38	115.17	101.71
1.0	124.98	113.56	106.73	95.26
4	56.92	54.75	53.31	50.60
8	34.3	33.56	33.04	32.04
10	28.79	28.27	27.90	27.19
		$\epsilon_r = 4$		
0.1	137.60	126.19	112.69	94.68
0.4	100.17	95.59	89.26	79.01
0.8	78.11	75.59	71.94	65.57
1.0	70.88	68.84	65.87	60.58
4	31.21	30.85	30.29	29.22
8	18.36	18.24	18.05	17.68
10	15.23	15.20	15.07	14.81
		$\epsilon_r = 4.6$		
0.1	130.145	119.501	106.856	89.932
0.4	94.533	90.279	84.411	74.853
0.8	73.616	71.281	67.907	61.996
1.0	66.766	64.887	62.140	57.240
4	29.288	28.955	28.445	27.460
8	17.195	17.084	16.912	16.571
10	14.306	14.230	14.111	13.875
		$\epsilon_r = 8$		
0.1	102.94	94.87	85.17	72.05
0.4	74.28	71.12	66.73	59.50
0.8	57.62	55.90	53.40	48.98
1.0	52.18	50.80	48.77	45.12
4	22.64	22.40	22.03	21.31
8	13.21	13.13	13.01	12.76
10	10.97	10.92	10.83	10.66
		$\epsilon_r = 12$		
0.1	85.76	79.16	71.21	60.39
0.4	61.69	59.14	55.58	49.68
0.8	47.76	46.38	44.36	40.78
1.0	43.22	42.12	40.48	37.53
4	18.65	18.46	18.16	17.59
8	10.86	10.79	10.69	10.50
10	9.01	8.96	8.90	8.76
		$\epsilon_r = 16$		
0.1	75.04	69.33	62.42	53.01
0.4	53.89	51.69	48.62	43.52
0.8	41.69	40.50	38.76	35.67
1.0	37.71	36.76	35.35	32.81
4	16.23	16.06	15.81	15.32
8	9.43	9.38	9.29	9.13
10	7.82	7.79	7.73	7.61

*Reference 3 sample problem is the same as that presented here, but the result for w is given as 2.75 mm. Since the reverse procedure here produces a Z_0 of 49.9974 ohms, which is in good agreement with the initial value of 50 ohms specified, perhaps a typographical error accounts for this discrepancy.

The HP-67/97 program was written in this manner to provide a built-in self-check. No graphs are provided for this configuration except for $\epsilon_r = 1$ in **fig. 19.** This is because their number is too numerous to present all of the variables. **Table 43,** for which the value of Z_0 is given for useful values of w/h versus t/h, also provides for values of ϵ_r of 1, 4, 8, 12, and 16. From these data additional graphs can be prepared covering specific ranges of interest.



stripline centered between parallel planes

Previously, the impedance of a stripline centered between parallel planes could be determined only from the work published *in reference* 6 and a subsequent distillation in reference **4.** However, H.A. Wheeler, in 1978 (reference 2), provided an empirically derived formulation permitting direct synthesis with excellent accuracy. This is done in much the same way as for a stripline over a plane previously discussed.

$$\frac{\Delta w}{t} = \frac{1}{\pi} \ell n \frac{e}{\sqrt{\left(\frac{1}{\frac{4h}{t}+1}\right)^2 + \left(\frac{1}{4\pi \frac{w'}{t} - 0.26}\right)^m}} \quad (50)$$

$$\frac{w'}{h} = \frac{16}{\pi} \frac{\sqrt{(e^{4\pi r}-1)+1.568}}{(e^{4\pi r}-1)} \quad (51)$$

$$w = w' - w \quad (52)$$

where

$$r = \frac{\sqrt{\epsilon_r} Z_0}{377} \quad (53)$$

$$m = \frac{6}{3+\frac{t}{h}} \quad (54)$$

table 44. Method of calculating stripline width:

1. Specify h, t, Z_0, and ϵ_r.
2. Determine $\frac{\Delta w}{t}$ (from **eq. 50**).
3. Determine $\frac{w'}{h}$ (from **eq. 51**).
4. Determine w (from **eq. 52**).

table 45. Method of calculating stripline Z_0:

1. Determine $\frac{\Delta w}{t}$ (from **eq. 55**).
2. Determine w' (from **eq. 56**).
3. Determine Z_0 (from **eq. 57**).

When it is desired to calculate Z_0 with h, t, w, and ϵ_r known, the method is described in **table 45.** The formulation used to calculate Z_0 is:

$$\frac{\Delta w}{t} = \frac{\ell n}{\pi} \frac{e}{\sqrt{\left(\frac{1}{\frac{4h}{t}+1}\right)^2 + \left(\frac{1}{4\pi \frac{w}{t}+1.1}\right)^m}} \quad (55)$$

$$w' = w + \Delta w \quad (56)$$

$$Z_0 = \frac{30}{\sqrt{\epsilon_r}} \ell n \left[1 + \frac{1}{2}\left(\frac{16h}{\pi w'}\right)\left[\left(\frac{16h}{\pi w'}\right) + \sqrt{\left(\frac{16h}{\pi w'}\right)^2 + 6.27}\right]\right] \quad (57)$$

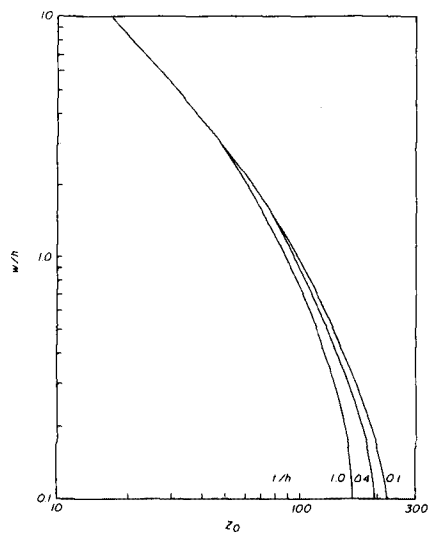


fig. 20. Z_0 **versus** w/h **for values of** t/h **for a stripline between parallel planes,** $\epsilon_r = 1$.

where m is defined in **eq. 54.**

Table 46 is an HP-67/97 program for calculating Z_0 and w. **Table 47** identifies the storage registers used, and **table 48** describes how the program is controlled.

A sample problem was run using $Z_0 = 50$, $\epsilon_r = 1$, $h = 1$, and $t = 0.0625$. The w yielded was **2.7687.** The reverse was run using the w just calculated. The resulting Z_0 was **51.31,** which is within the limits described in reference 2.

Fig. **20** displays w/h versus various values of t/h and the resulting Z_0 for $\epsilon_r = 1$; that is, air. **Table 49** provides the same data for various values of ϵ_r, which are not plotted.

table 46. HP-67/97 program for calculating w and Z_0 for a stripline between ground planes:

step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code
001	*LBLA	21 11	052	÷	− 24	103	R/S	51	154	STO9	35 09
002	STO0	35 00	053	1	01	104	*LBL9	21 09	155	1	01
003	RTN	24	054	6	06	105	RCL5	36 05	156	6	06
004	*LBLB	21 12	055	x	− 35	106	3	03	157	Pi	16-24
005	DSP4	− 63 04	056	Pi	16-24	107	+	− 55	158	÷	− 24
006	$\sqrt{X}$	54	057	÷	− 24	108	1/X	52	159	RCL3	36 03
007	STO1	35 01	058	STO8	35 08	109	6	06	160	x	− 35
008	RTN	24	059	RCL3	36 03	110	x	− 35	161	RCL9	36 09
009	*LBL8	21 08	060	x	− 35	111	STO6	35 06	162	÷	− 24
010	RCL0	36 00	061	STO9	35 09	112	RTN	24	163	X^2	53
011	x	− 35	062	RCL4	36 04	113	*LBL2	21 02	164	6	06
012	3	03	063	÷	− 24	114	RCL8	36 13	165	.	− 62
013	7	07	064	.	− 62	115	RCL4	36 04	166	2	02
014	7	07	065	2	02	116	÷	− 24	167	7	07
015	÷	− 24	066	6	06	117	1	01	168	+	− 55
016	STO2	35 02	067	−	− 45	118	.	− 62	169	$\sqrt{X}$	54
017	RTN	24	068	Pi	16-24	119	1	01	170	STOA	35 11
018	*LBLC	21 13	069	4	04	120	−	− 55	171	RCL3	36 03
019	STO3	35 03	070	x	− 35	121	Pi	16-24	172	RCL9	36 09
020	RTN	24	071	x	− 35	122	4	04	173	÷	− 24
021	*LBLD	21 14	072	1/X	52	123	x	− 35	174	STOE	35 15
022	STO4	35 04	073	RCL6	36 06	124	1/X	52	175	1	01
023	RCL3	36 03	074	Y^x	31	125	GSB9	23 09	176	6	06
024	÷	− 24	075	STOA	35 11	126	RCL6	36 06	177	Pi	16-24
025	STO5	35 05	076	RCL3	36 03	127	Y^x	31	178	÷	− 24
026	GSB9	23 09	077	4	04	128	STOA	35 11	179	x	− 35
027	R/S	51	078	x	− 35	129	RCL3	36 03	180	RCLA	36 11
028	*LBLa	21 16 11	079	RCL4	36 04	130	4	04	181	+	− 55
029	STOI	35 46	080	÷	− 24	131	x	− 35	182	STOA	35 11
030	GSB1	23 45	081	1	01	132	RCL4	36 04	183	RCLE	36 15
031	*LBLE	21 15	082	+	− 55	133	÷	− 24	184	1	01
032	STOC	35 13	083	1/X	52	134	1	01	185	6	06
033	RTN	24	084	X^2	53	135	+	− 55	186	Pi	16-24
034	*LBL1	21 01	085	RCLA	36 11	136	1/X	52	187	÷	− 24
035	GSB8	23 08	086	+	− 55	137	X^2	53	188	x	− 35
036	Pi	16-24	087	$\sqrt{X}$	54	138	RCLA	36 11	189	2	02
037	4	04	088	1/X	52	139	+	− 55	190	÷	− 24
038	x	− 35	089	1	01	140	$\sqrt{X}$	54	191	RCLA	36 11
039	x	− 35	090	e^x	33	141	1/X	52	192	x	− 35
040	e^x	33	091	x	− 35	142	1	01	193	1	01
041	1	01	092	LN	32	143	e^x	33	194	+	− 55
042	−	− 45	093	Pi	16-24	144	x	− 35	195	LN	32
043	STO7	35 07	094	÷	− 24	145	LN	32	196	3	03
044	1	01	095	STOB	35 12	146	Pi	16-24	197	0	00
045	.	− 62	096	RCL4	36 04	147	÷	− 24	198	x	− 35
046	5	05	097	x	− 35	148	STOB	35 12	199	RCL1	36 01
047	6	06	098	STOC	35 13	149	RCL4	36 04	200	÷	− 24
048	8	08	099	CHS	− 22	150	x	− 35	201	STO0	35 00
049	+	− 55	100	RCL9	36 09	151	STOD	35 14	202	R/S	51
050	$\sqrt{X}$	54	101	+	− 55	152	RCLC	36 13			
051	RCL7	36 07	102	STOD	35 14	153	+	− 55			

table 47. Register contents for HP-67/97 program for calculating w and Z_0 for stripline between ground planes:

STO 0	Z_0	STO 8	w'/h
STO 1	$\sqrt{\epsilon_r}$	STO 9	w'
STO 2	r	STO A	INTERIM CALC
STO 3	h	STO B	$\Delta w/t$
STO 4	t	STO C	w
STO 5	t/h	STO D	Δw
STO 6	m	STO E	h/w'
STO 7	$e^{4\pi r}$		

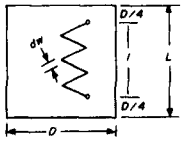
table 48. HP-67/97 program control for calculating w and Z_0 for a stripline between ground planes:

enter Z_0	press A
enter ϵ_r	press B
enter h	press C
enter t	press D
enter w	press E

Enter any four of the above; select one of the following parameters,

w press 1
Z_0 press 2

and press fa.



helical resonator

Helical resonators are a form of transmission line extensively used in vhf/uhf applications. The major advantage is high unloaded Q in a very small physical space, thus permitting the realization of compact filters in this frequency spectrum.

Using the reasonably accurate, simple formulation presented in references 4 and 8, an HP-67/97 program was written permitting the design to be realized. Reference 9 provides a detailed design procedure and analysis.

The helical resonator configuration is shown in **fig. 21**. The method for calculating the desired dimensions is given in **table 50**. The detailed program steps are shown in **table 51** with the storage-register contents identified in **table 52**. Program control is shown in **table 53**.

A sample problem was run. The line Z_0 was specified at 70 ohms at 144 MHz, and all the resonator parameters were determined: $D = 0.97$ *inch*, $d = 0.53$ *inch*, $L = 1.46$ *inches*, $n = 13.57$ *turns*, $Q\mu$ *circular* $= 583$, and $Q\mu$ *square* $= 700$. Where square and circular, refer to the outside cavity configuration.

table 62. Register contents for HP-67/97 program for calculating helical-resonator parameters.

STO 1	Z_0
STO 2	F
STO 3	D
STO 4	d
STO 5	L
STO 6	n
STO 7	$Q\mu$ circular
STO 8	$Q\mu$ square
STO 9	PITCH

table 49. Values of Z_0 for w/h versus t/h for various values of ϵ_r for a stripline between parallel planes:

w/h	t/h 0.1	0.2	0.4	1.0
		$\epsilon_r = 1.0$		
0.1	229.34	221.95	206.47	166.70
0.4	151.45	149.38	144.46	127.64
0.8	112.06	111.05	108.57	99.43
1.0	99.79	99.00	97.06	89.77
4	38.33	38.21	37.93	36.78
8	21.14	21.12	21.02	20.66
10	17.29	17.26	17.21	16.97
		$\epsilon_r = 4$		
0.1	114.67	110.97	103.24	83.35
0.4	75.72	74.69	72.23	63.82
0.8	56.03	55.53	54.29	49.72
1.0	49.89	49.50	48.53	44.88
4	19.16	19.11	18.96	18.39
8	10.57	10.55	10.51	10.33
10	8.64	8.63	8.60	8.48
		$\epsilon_r = 8$		
0.1	81.08	78.47	73.00	58.94
0.4	53.54	52.82	51.10	45.13
0.8	39.62	39.26	38.39	35.15
1.0	35.28	35.00	34.32	31.74
4	13.55	13.51	13.41	13.00
8	7.47	7.46	7.43	7.31
10	6.11	6.10	6.08	6.00
		$\epsilon_r = 12$		
0.01	94.71	85.72	73.46	53.84
0.04	79.58	75.25	67.52	51.71
0.1	66.21	64.07	59.60	48.12
0.4	43.72	43.12	41.70	36.85
0.8	32.35	32.06	31.34	28.70
1.0	28.81	28.58	28.02	25.91
4	11.07	11.03	10.95	10.62
8	6.10	6.09	6.07	5.97

table 50. Method of calculating helical-resonator parameters:

1. Specify Z_0 (ohms) and frequency (MHz).
2. Calculate D, d, L, n, $Q\mu$ circular, $Q\mu$ square, and coil pitch from the equations below.

$$D = \frac{9800}{F Z_0}$$

$$d = 0.55D$$
$$L = 1.5D$$
$$n = \frac{1900}{F D}$$

$$Q\mu \text{ circular} = 50\sqrt{F D}$$
$$Q\mu \text{ square} = 1.2\, Q\mu$$
$$\text{coil pitch} = \frac{D^2 F}{2300} = \frac{L \cdot D/2}{n}$$

table 51. HP-67/97 program for calculating helical resonator parameters:

step	HP-97 key	HP-97 code	step	HP-97 key	HP-97 code
001	*LBLA	21 11	041	x	− 35
002	STO1	35 01	042	1/X	52
003	RTN	24	043	1	01
004	*LBLB	21 12	044	9	09
005	STO2	35 02	045	0	00
006	RTN	24	046	0	00
007	*LBLa	21 16 11	047	x	− 35
008	STOI	35 46	048	STO6	35 06
009	GSB1	23 45	049	R/S	51
010	*LBL1	21 01	050	*LBL5	21 05
011	RCL1	36 01	051	RCL2	36 02
012	RCL2	36 02	052	$\sqrt{X}$	54
013	x	− 35	053	RCL3	36 03
014	1/X	52	054	x	− 35
015	9	09	055	5	05
016	8	08	056	0	00
017	0	00	057	x	− 35
018	0	00	058	STO7	35 07
019	x	− 35	059	R/S	51
020	STO3	35 03	060	*LBL6	21 06
021	R/S	51	061	RCL7	36 07
022	*LBL2	21 02	062	1	01
023	RCL3	36 03	063	.	− 62
024	.	− 62	064	2	02
025	5	05	065	x	− 35
026	5	05	066	STO8	35 08
027	x	− 35	067	R/S	51
028	STO4	35 04	068	*LBL7	21 07
029	R/S	51	069	RCL3	36 03
030	*LBL3	21 03	070	X^2	53
031	RCL3	36 03	071	RCL2	36 02
032	1	01	072	x	− 35
033	.	− 62	073	2	02
034	5	05	074	3	03
035	x	− 35	075	0	00
036	STO5	35 05	076	0	00
037	R/S	51	077	+	− 24
038	*LBL4	21 04	078	STO9	35 09
039	RCL2	36 02	079	R/S	51
040	RCL3	36 03			

acknowledgments

Comments by S. Harrison, WB6PKA, Dr. R.M. Searing, and T.C. McDermott, III, N5EG, are gratefully acknowledged. The most valuable contributions were provided by B.L. Reardon, to whom the author is singularly indebted.

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table 53. HP-67/97 program control for calculating helical-resonator parameters:

enter Z_0	press A
enter F_{MHz}	press B
Enter both of the above; select one of the following parameters:	
D	press 1
d	press 2
L	press 3
n	press 4
$Q\mu$ circular	press 5
$Q\mu$ square	press 6
Pitch	press 7
and press fa.	

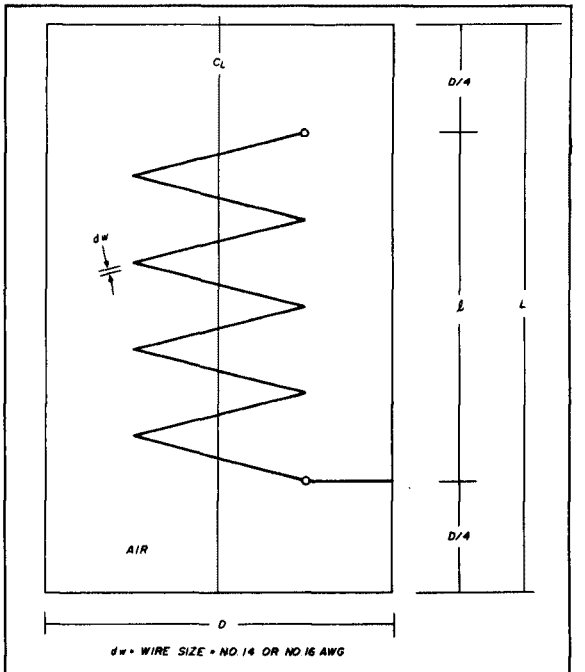


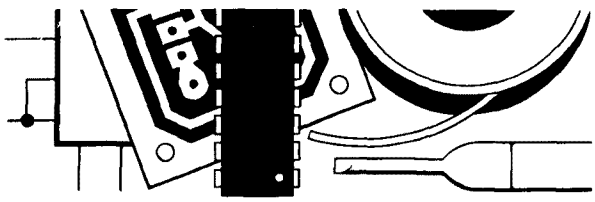
fig. 21. Helical reaonator configuration.

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the weekender



add fm to your receiver

The fm mode of operation has been around for a long while, but not until the two-meter rage had it been used extensively for Amateur communications. Fm has become commonplace on vhf and uhf frequencies, but now its use is becoming more and more popular in the 29.500 through 29.700 MHz range (10-meter fm). It has always been the forgotten mode on your lowband transceiver. If you wanted to pioneer this spectrum, a piece of commercial-band equipment was your only alternative. But wait. What have we here? Comtronics FM-80, Azden 2800, and now fm on the 901-DM. *There must be someone up there*!

Commercially built ham transceivers as well as many converted CB radios have generated new life to an almost forgotten part of the ten-meter band. Don't scoff at the mention of converted CBs, as these are among some of the top performers when properly converted.

Described here is a conversion that can be made to any receiver using a 455-kHz i-f to add true fm to its current capabilities. The circuit can be built on a piece of vector board approximately two inches (50 mm) square, allowing it to fit nicely in even the smallest transceiver.

By John LaMartina, K3NXU, 105 Skyview Drive, Shrewsbury, Pennsylvania 17361

The chip selected is an MC 1358. Although designed for TV sound service, it works excellently at 455 kHz for nbfm applications. This chip functions as an i-f amplifier, limiter, fm detector and audio driver.

basic operation

The 455-kHz i-f input to the IC is acquired from the last 455-kHz i-f amplifier. The fm signal is detected and set to the i-f by transformer T1. The audio is fed

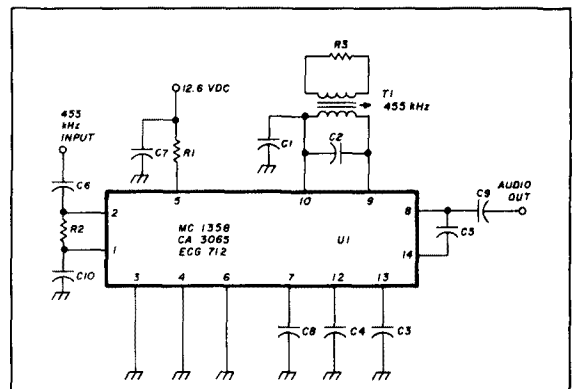


fig. 1. Schematic of the conversion circuit for adding fm to an a-m receiver.

to an audio driver with more than enough gain to properly drive your existing audio amplifier.

construction

The use of a low-profile IC socket doesn't affect

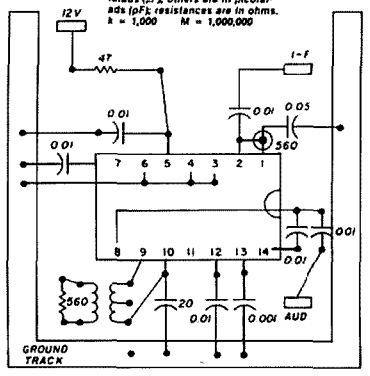


fig. 2. Parts placement on Vector™ board.

the performance of the i-f stage. Personally, I prefer to use them whenever possible (cheap insurance). In addition, try to keep all leads as short as possible. Capacitor C2 may not be required if the transformer selected is already at resonance.

installation

The existing detector stages of the receiver are left intact so as to not disable the S-meter and squelch function.

1. Connect the 455-kHz i-f input to the base of the last i-f amplifier transistor.

2. The audio output pad of the fm board connects to the top of the volume control pot. The existing lead to this point must be removed or switched off so as to not receive fm and the existing receiver mode simultaneously.

3. Connect 12 Vdc and ground from the receiver to the conversion board.

adjustment

The only adjustment necessary will be that of transformer T1. This should be set for maximum audio response upon the reception of a signal, either on the air or from an fm signal/tone generator. If too much drive is being delivered from the audio driver stage, insert a 100k resistor between C5 and the top of the volume control.

closing comments

I have installed several of these fm conversions and have had complete success with each.

Predrilled PC boards with complete wiring diagram are available from the author for $5.00 each.

ham radio

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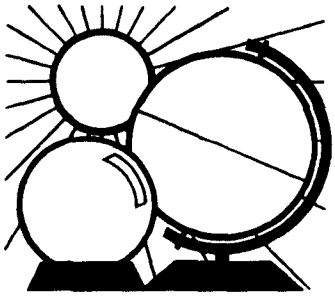
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weather affects DX, right?

Besides keeping us indoors or outside? Yes! March and April are months in which weather is usually a series of spring storms bringing rain to much of our country. These storms are usually fronts of warm and cold air, which produce the year's first major thunderstorms. Thunderstorms mean noise (static) that affects the signal-to-noise ratio of our receivers, decreasing readability.

Thunderstorm static propagated from far off is the main overall noise level of our lower-frequency hf bands. The average noise from the thunderstorms all over the world going on at once makes this noise level. However, as a particular storm front comes near, a significant increase in the noise level can be heard. The first notice of this noise increase is at a one-hop distance away (about 600-1200 miles or 960-1920 km) when the storm front is about a day or so to the west of your location. Next, the noise will usually decrease as the storm moves closer; that is, until it is within a ground-wave distance of 50-60 miles or 80-96 km (near line of sight). Thunderstorm static is then worse, mainly individual crashes, and it becomes part of the local noise. As the storm moves away a similar decrease, then an increase, is heard in a day or so again as the front moves on. You can check this out for your location by coordinating the TV weather program with your operating/listening experience. The effect is more noticeable on the lower frequency bands.

In looking for the rare DX, you may want to make the best use of your time by tracking the storms to give you the best chance at quiet noise conditions. Remember, too, the DX station's operating times and frequencies. An article in the November, 1980, issue of *CQ* lists the foreign national holidays (consider when the DX is home from work), and a *QST* article (January, 1975) points out the best DX frequencies in each band.

Toward the end of March (associated with the equinox, which is on March 20 at 1703 UT), the geomagnetic field is easily disturbed. The equatorial plane of the sun lines up through space with the earth's equator, giving particles a more direct path to the earth's polar regions. Disturbances are prevalent under this condition. DX can be from unusual locations because of the ionosphere's erratic movements. East-west paths are generally poorer; otherwise during undisturbed times, over-the-pole DX paths are better during the equinox season.

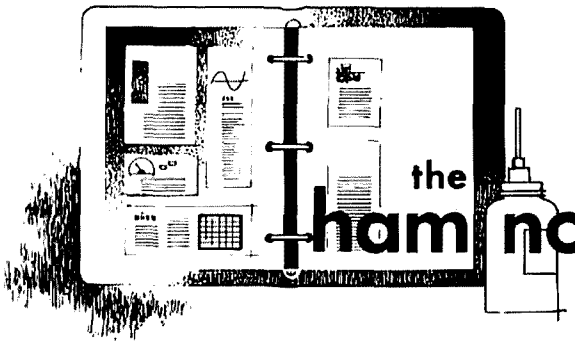
band-by-band summary

Six meters will provide some excellent openings to South Africa from the eastern U.S. and from the western and central U.S. to Australia and New Zealand around local noontime. The openings are more probable during *high* solar flux values.

Ten, fifteen, and twenty meters will be full of signals from morning into early evening almost every day and to most areas of the world. The openings will be shorter on the higher bands and concentrated more near noon for the path of interest. High solar flux values *and* geomagnetic disturbance will favor these bands for transequatorial contacts. Noise effects are not too noticeable.

Forty, eighty, and one-sixty meters are the night Dxer's bands. The bands are open beginning just before sunset and lasting until just as the sun comes up on the path of interest. Except for daytime short-skip signal strengths, high solar flux values don't affect these bands much. Geomagnetic disturbances, which will be more evident near the equinox, cause much signal attenuation and fading on polar paths. The effects of these disturbances are less on these bands, although noise will be spasmodic and very noticeable on these lower-frequency bands.

GMT	PST	WESTERN USA N	NE	E	SE	S	SW	W	NW	MST	MID USA N	NE	E	SE	S	SW	W	NW	CST	EST	EASTERN USA N	NE	E	SE	S	SW	W	NW
0000	4:00	10	20	10	15	10	10	10*	10	5:00	10	20	10	10	10	10	10	10	6:00	7:00	10	20	10	10	10	10	10	10
0100	5:00	10	20	10	15*	10	10	10	10	6:00	10	20	15	10	10	10	10	10	7:00	8:00	10	20	15	15	15	10	10	10
0200	6:00	10	20	15	10	10	10	10	15	7:00	10	40	15	10	15	10	10	10	8:00	9:00	15	20	15*	15	15	10	10	10
0300	7:00	10	20	15	10	10	10	10	15	8:00	15	40	15	15	15	10	10	15*	9:00	10:00	15	20	20*	15	15	10	15	10
0400	8:00	10	40	20	15	15*	10	10	15	9:00	15	40	20	15	15	10	10	15	10:00	11:00	20*	40	20	15	15	15	15	10
0500	9:00	—	—	20*	15	15	10	10	20	10:00	15	40*	20	15	15	15	15	15	11:00	12:00	20	40	20	15	20	15	15	15
0600	10:00	—	20	20	15	15	10	10	20	11:00	—	—	20*	15	15	15	15	20	12:00	1:00	20	40	15	15	20	20*	20	20*
0700	11:00	—	—	20	15	15	15	10	20	12:00	—	—	20	20*	20	15	15	20	1:00	2:00	—	40	20	20	20	20*	20	20
0800	12:00	20	—	20	20	20	15	15*	20	1:00	20	—	20	15	20	15	15	20	2:00	3:00	—	40	20	20	20	20*	20	20
0900	1:00	20	—	20	20	20	15	15	—	2:00	20	—	20	20	20	15	20	20	3:00	4:00	—	20	—	20	20	20	20	20
1000	2:00	20	—	—	20	20	15	15	—	3:00	—	20	—	20	20	20	20	20	4:00	5:00	20	20	—	20	20	20	20	40*
1100	3:00	20	—	—	20	20	15	20	—	4:00	—	20	—	20	20	20	20	20	5:00	6:00	20	15	15	15	20	20	20	40*
1200	4:00	20	40*	—	15	20	20	20	20	5:00	—	20	—	15	20	20	20	—	6:00	7:00	20	15	10	10	20	20	20	40*
1300	5:00	20	20	—	15	—	20	20	20	6:00	20	15	15	15	—	20	20	20	7:00	8:00	—	10	10	10	—	—	15	20
1400	6:00	20	20	15	10	20	20	20	20	7:00	20	15	10	10	—	15	20	20	8:00	9:00	15	10	10*	10	—	20*	15	20
1500	7:00	20	20	15	10	20	20*	15	20	8:00	15	10	10	10	—	15	15	20	9:00	10:00	15	10	10*	10	—	15	15	20
1600	8:00	20*	15	15	10	—	15	15	20	9:00	15	10	10	10	15	15	15	20	10:00	11:00	15	10	10	10	—	15	20	20
1700	9:00	15	15	15*	10	—	15	—	20	10:00	15	10	10	10	15	15*	—	—	11:00	12:00	—	10	10	10	—	15*	—	20
1800	10:00	15	10	10	10	15	10	—	20	11:00	15	10	10	10	15	10	—	—	12:00	1:00	—	10	10	10	15	10	—	20
1900	11:00	15	10	10	10	15	10	—	20	12:00	15	10	10	10	10	10	—	—	1:00	2:00	—	15	10	10	10	10	20	20
2000	12:00	—	10	10	10	10	10	10	20	1:00	15	15	10	10	10	10	10	15	2:00	3:00	—	15	10	10	10	10	10	15
2100	1:00	—	20	10	10	10	10	10*	15*	2:00	—	15	10	10	10	10	10*	15	3:00	4:00	—	15	10	10	10	10	10	15
2200	2:00	10	20	10	10	10	10	10	10	3:00	—	20	10	10	10	10	10	10	4:00	5:00	15	20	10	10	10	10	10	20
2300	3:00	10	20	10	15	10	10	10*	10	4:00	15	20	10	10	10	10	10*	10	5:00	6:00	15	20	15	10	10	10	10	20
	MARCH	ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN		ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN			ASIA FAR EAST	EUROPE	S. AFRICA	CARIBBEAN S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN



the ham notebook

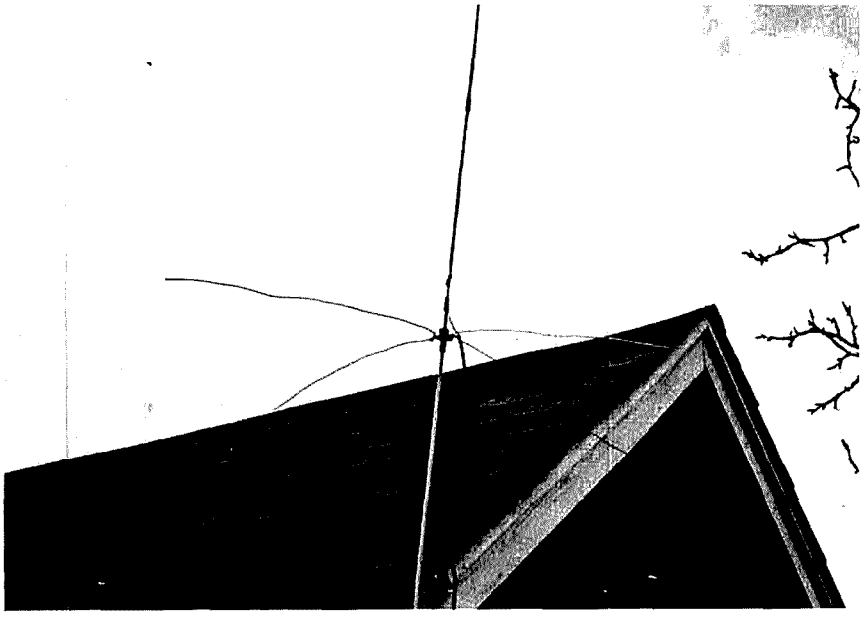
inexpensive five-eighth wave ground plane

A year or so ago, my wife won a bicycle flag as a door prize at a meeting. I do own a bicycle but I have no need for such a flag. The other day, I took this work of art out from behind the bedroom door and transformed it into a 2-meter antenna. I measured off approximately 4 feet (1.2 meters) of wire, brought it down the "flag pole" and wound a ten-turn coil at the bottom. I had a coaxial chassis connector (with a missing center conductor) which I drilled to fit the plastic pole. I then soldered on four 20-inch (50-cm) radials made of No. 12 (2.1-mm) wire. I wrapped the pole with tape, just under the radials, to hold them at the proper level. I soldered the shield of some RG-58/U cable to the radials, and the center conductor to the bottom of the coil.

I fired up the 2-meter rig, and connected an SWR meter into the line; it showed about 2.5:1. I took off a turn of wire; this dropped the SWR to 2:1. I then started cutting the vertical wire an inch at a time, and cut once too often. By pushing all of the coil turns tight together, I came up with 1.1:1 — close enough.

The photograph shows the bicycle-flag antenna in place on the house.

Bob Baird, W7CSD



the best way to get an antenna into a tree

For many years the Los Alamos Amateur Radio Club has set up Field Day in the nearby Jemez Mountains, which are well supplied with tall Douglas fir and spruce trees. Each year we struggled with the problem of getting the antennas up into the trees. We've tried everything: climbing, throwing a weighted line, using a bow and arrow. Finally, about three years ago, K5QIN developed an ingenious but inexpensive device, which was the ultimate solution.

A slingshot was wedded to a spin-casting reel. The *Wrist Rocket* brand slingshot uses surgical rubber tubing as the elastic; it's surprisingly powerful. Fastened to the handle of the slingshot is the spin-casting reel. A one-ounce sinker is tied to the fish line. For ease of finding the sinker, I tied on a piece of bright red tape.

To use, merely unlock the reel, stand near the base of the tree, and fire upward at about a 60-degree angle. The weight easily clears 60-80 foot (18-24) meter) trees, and almost invariably falls all the way to the ground. Remove the sinker from the end of the line (cut it — fish line is cheap) and tie on a light nylon twine, such as 50-120 pound (23-54 kg) test. Then reel back the fish line steadily, until the twine returns to the ground. You can then connect whatever stronger line is needed to raise the antenna.

The advantages of this system are these:

1. It's inexpensive. I bought a spincast reel on sale for less than $3, spent $5 on the slingshot, and got 2000 feet (610 meters) of 6-pound-test (2.7-kg) monofilament for about $1.25. One ounce (28.4g) sinkers cost about 12 cents.

2. If the line becomes tangled, just break it, abandon it, and try again. This is not the case with a bow and arrow, as archers are reluctant to lose expensive arrows.

3. The small weight rarely tangles in the trees.

We have built several of these and find them among the handiest devices ever invented.

Alan Hack, WA5VLX

antenna bridge calculations

Here is a composite version, using the TRS80, Level 2, of Anderson's fine series of programs, first listed in the May, 1978, issue of *ham radio*. Readers should refer to that article for the formulas used and other background material.

Lines 10, 17, 20, and 300, as written, should duplicate the results given in **programs 1** and **2** using the same input data, and can be edited as required.

Paul Manacek, K6GK

```
5   Print, "Smith Chart Rotation"        ↑ = "UP ARROW"
6   Print: Print
8   Input "Enter next freq. in mhz";F
10  Z0=50
12  Input "Enter noise bridge 'RP' Reading";R
15  Input "Enter noise bridge 'C' reading in picos";C
17  V=.66
20  L=60
35  R1=.006388
45  X= -159155/(F*C)
50  A=(R*X↑2)/(R↑2+X↑2)
60  B=(X*R↑2)/(R↑2+X↑2)
65  Input "Enter value of series extender (0 if not used)"
    ;SE
75  Print
80  A1=A-SE
85  Print "The line input Z (RG,XG)="A1,B
90  A2=SQR((A1+Z0)↑2+(B↑2))
95  B2=SQR((A1-Z0)↑2+(B↑2))
100 Print "the swr is",(A2+B2)/(A2-B2)
110 K=R1*(L/V)
120 XK= Tan (K*F)
130 RG=A1
140 XG=B
150 RO=Z0
160 A=(XG-RO*XK
170 B=(RO+XG*XK)
180 D=RG*XK
190 N= -D
200 X=((RG*B)+(A*N))/(B*B+N*N)
210 Y=((B*A)-(RG*N))/(B*B+N*N)
220 Z=X*RO
230 J=RO*Y
240 Print
250 Print "Antenna Z (No-Loss Line) is";Z,J
260 A2=SQR((Z+RO)↑2+(J↑2))
270 B2=SQR((Z-RO)↑2+(J↑2))
280 Print "The SWR is", (A2+B2)/A2-B2)
290 Print
300 DB=.8
310 N=8.686
320 E=2.718282
330 A=DB/N
340 B=K*F
350 D=E↑(4*A)=1+2*E↑(2*A)*Cos(2*B)
360 RA=((E↑(4*A)-1))/D
370 B1=2*E↑(2*A)*Sin(2*B)
380 A2=D
390 P=A2*A2
400 M=(A2+B1)/(A2*A2)
410 Print
420 Print "Complex Attenuation Factors (RA,XA)=";RA,M
430 Print
440 Print "Next rotation is for Lossy Lines": Print
450 Input "Enter RG from top of screen";RS
460 Input "Enter XG";XG
470 Input "Enter RA";RA
480 Input "Enter XA";XA
490 A4=(RS-RA*RO)
500 B4=(RO-RS*RA+XG*XA)
510 D4=RA*XG
520 G4=RS*XA
530 H4=C4
540 I4=D4+G4
550 L4=RO*XA
560 M4=O4
570 N4=XG-L4
580 O4=A4+M4
590 P4=N4
600 Q4=B4-H4
610 T4=I4
620 V4=((O4*Q4)+(P4*T4))/(Q4*Q4+T4*T4)
630 W4=((Q4*P4)-(O4*T4))/(Q4*Q4+T4*T4)
640 Y4=(V4*RO
650 Z4=RO*W4
660 Print:Print
670 Print "Antenna Z, (lossy line) is",Y4,24
680 Print
690 A3=SQR((Y4+RO)↑2+(Z4↑2))
700 B3=SQR((Y4-RO)↑2+(Z4↑2))
710 Print "The Swr, with losses, is",(A3+B3)/(A3-B3)
720 Print:Print
730 Run 8
```

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Coming Events

ACTIVITIES

"Just What the Doctor Ordered!"

CALIFORNIA: The 6th West Coast Computer Faire on April 3-5 in San Francisco. Program includes 50 to 120 speakers, over 400 exhibits, and between 20,000 and 24,000 are expected. More info: Jim Warren (415) 851-7075.

MARYLAND: Greater Baltimore Hamboree and Compuertest on March 29 at the Maryland State Fairgrounds, Timonium, Maryland. Gates open at 8:00. Admission is $3.00. Speakers, demonstrations, indoor flea market, outdoor tailgating, large indoor show area for dealers/commercial displays plus prizes, free parking and much more. Exit 16-A of I-83, two miles north of I-695 near Baltimore. Talk-in on 146.07/67 and 146.34/94. More information and table reservations: G.B.H. & C., 2136 Pine Valley Dr., Timonium, Maryland 21093 or (301) 321-1404.

MISSOURI: Missouri State ARRL Convention/Northwest Missouri Hamfest on April 11-12. Old airport, Kansas City, Missouri. Over 500,000 feet of commercial, flea market, forums, free parking. Information: P.H.D., P.O. Box 11, Liberty, Missouri 64068.

NEBRASKA: The Hamboree 5 on March 21 at the Marina Inn in So. Sioux City. Doors open at 9:00. Exhibits, Flea Market, contests, programs, dinner banquet and more. More info: Dick Pitner, WØFZO or Glen Holder, KØTFT. Advanced registration: Jerry Smith, WØDUN, Box 14, Akron, Iowa 51001.

NEW HAMPSHIRE: Auctionfest '81 on March 21 sponsored by the Interstate Repeater Society, P.O. Box 94, Nashua, NH 03106. Location: Hilton in Merrimack. Doors open at 9:00 AM. Vendor exhibits and more. $5.00 and $75.00 for Flea Market rooms. Auction begins at 11:00 AM. For accommodations, reservations, more information: write WB1FRE.

NEW JERSEY: Chestnut Ridge Radio Club's Ham Radio and Computer Flea Market on April 4 from 9:00 to 3:00 at the Educational Building, Saddle River Reform Church, East Saddle River at Weiss Road in Upper Saddle River, New Jersey. No admission fee. Tables are $10.00 and tailgating is $5.00. Contact Jack Meagher, W2EHD, (201) 768-8360 or Neil Abitabilo, WA2EZN (201) 767-3575.

NEW JERSEY: Annual Flemington, N.J. Hamfest Saturday, March 21 from 8:30 to 3:00 at the Hunterdon Central High School Field House. 20,000 square feet of heated indoor area. Gigantic flea market, 200 tables, major manufacturers, informative seminars. Bring the XYL, kids and friends. Flemington is a tourist area. Talk in 146.52, 147.375, 147.015, 224.12. Admission $3.00 donation. For reservations or info call 201-788-4080 or write Cherryville Repeater Assn. c/o W2FCW, Box 76, Farview Ave., Annandale, N.J. 08801.

NEW JERSEY: The Old Bridge Radio Association's first annual auction of ham radio, electronic, and computer gear on March 1 at the Cheesequake Firehouse, Routes 35 and 9, in Old Bridge. Exhibition begins at 11 AM, sale at noon. Refreshments available. More info, call Fred at (210) 257-8753.

NORTH CAROLINA: The 1981 Charlotte Hamfest on March 21 and 22 at the Charlotte Civic Center. The Hamfest and the North Carolina State ARRL Convention will bring more than 8,000 hams and their wives for this electronic feast. For more info: Rick Richardson, KA4EHU, 4609 Montclair Ave., Charlotte, NC 28211.

OHIO: The third annual Lake County Amateur Radio Association Lake County Hamfest on March 29 at Madison High School, Madison. Admission: $2.50 in advance and $3.00 at the door. Free parking, all displays are indoors, plus much more. Talk-in on 147.81/21. Information and reservations: SASE Lake County Hamfest Committee, 5555 Anaconda Rd., Mentor, Ohio 44060. (216) 953-9784.

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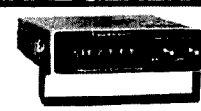
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PENNSYLVANIA: Penn Wireless Association, Inc. will hold its Tradefest '81 on March 29 at the National Guard Armory, Southhampton Rd. and Roosevelt Blvd., (Rte. #1) ½ mile south of the Pennsylvania Turnpike exit #28. General admission is $3.00. Prizes, refreshments, displays and surprises. Talk-in on 146.115/715 and .52. Contact Thomas Gallagher, WB3DJF, P.O. Box 734, Langhorne, Pennsylvania 19047.

TEXAS: Midland Amateur Radio Club's annual swapfest on March 14 from 1:00 to 7:00 and March 15 starting at 8:00. Doorprizes and more. Pre-registration is $4.50 or $5.00 at the door. Talk-in on 146.16/146.76.

WISCONSIN: The Madison Area Repeater Association's ninth annual Madison Swaptest on April 5 at the Dane County Exposition Center Forum Building in Madison. Exhibits, flea market, door prizes and more. $2.50 in advance and $3.00 at the door. Talk-in on 146.16/.76. Reservations and information: M.A.R.A., P.O. Box 3403, Madison, Wisconsin 53704.

SWEDEN: The International Radio Amateur Meeting in Goteborg on April 4 and 5. All interested hams are invited. Includes shows, exhibitions, lectures, special displays plus more. The Swedish Maritime Mobile Radio Club and the Scandinavian Amateur Radio Teletype Group are having their annual meetings. Exhibitors and hams outside of Sweden are also welcome.

OPERATING EVENTS

MARCH 21st - 22nd: Tennessee QSO Party from 2100Z (the 21st) to 0500Z (the 22nd) and from 1400Z to 2200Z on the 22nd. Tennessee stations give signal report and county. Out of state, give signal report and state, province or country. Same station on different bands allowed. CW frequencies: Approximately 50 from bottom of each band. Phone: 3980, 7280, 14280, 21380, 28680. Novices within their own bands. Deadline for logs: May 1, 1981. Send business sized SASE with log. More info: SASE Dave Goggio, W4OGG, 1419 Favell Dr., Memphis, Tennessee 38116.

MARCH 21st - 23rd: B.A.R.T.G. Spring RTTY Contest 1981. From 0200 GMT Saturday until 0200 GMT Monday. Total contest is 48 hours, but no more than 30 hours of operation is permitted. 18 hours of non-operating time may be taken at any time, but no less than 3 hours at a time. Must be summarized. Bands: 3.5, 7.0, 14.0, 21.0 and 28.0 MHz. Amateur bands. More info or logs (deadline: May 31st) SASE to Ted Double, G8CDW, 89, Linden Gardens, Enfield, Middlesex ENGLAND, EN1 4DX.

MARCH 28th AND 29th: YL ISSB QSO Party 1981. CW from 0001 GMT on the 28th to 2359 GMT on the 29th. Two 6 hour rest periods required. Phone from 0001 GMT on April 18th to 2359 GMT on the 19th. Two 6 hour rest periods required. YL/OM and DX/WK teams allowed. CW frequencies: 3665, 7070, 14070, 21070; Phone: 3925, 7290, 14332, 21373, 28673. Listen for DX on 3765 and 7090. More info: SASE to Lyle F. Shaw, KC4LF, 6329 Fairway Blvd., Apollo Beach, Florida 33570.

MARCH 28th AND 29th: Spring VHF QSO Party sponsored by the Ramapo Mountain ARC from 1800Z Saturday until 0400Z on Sunday. Exchange signal report and ARRL section. FM operation not permitted below 450 MHz. Use ARRL VHF QSO Party or similar forms or SASE to R.M.A.R.C. for entry forms and/or more information. Deadline: April 27th. Ramapo Mountain ARC, P.O. Box 364, Oakland, NJ 07436.

CENTURY 21 ARC — Low power — QRP'ers — CW nets — Contests — Awards — SASE KA4EBW.

ATTENTION FIREFIGHTERS! A firefighter net is being formed and will be operating on 10 meters. Times are 1500Z, 2100Z and 0100Z. The frequency is 28.7 MHz. More information: SASE and four first class stamps to Claude L. Fant, Jr., KA8HBU, 328 Harrison Ave., Hamilton, Ohio 45023. You will be sent a list of firefighters in the net and other information.

AWARD INFORMATION: The "10-K" and "20-K" award, formerly issued by the CHC, is available from WA6CPP, 13779 North Wells Lane, Lodi, California 95240. Work 10 (or 20) stations in the outlying territories and possessions with the miscellaneous K calls (KG4, KC8, KP6, etc.). Send log data and #10 SASE to WA6CPP. Send 3 units postage for return in mailing tube. OX stations send 2 IRC, CPP will supply the envelope. Limited supply.

OCTOBER 23, 1980 - OCTOBER 23, 1981: The New Bern Amateur Radio Club is sponsoring "The Swiss Bear Award." This award is given for working three different amateur stations in the New Bern area within the above time period. Extracts from logs for QSO's, along with a SASE or two IRC's (for DX stations) should be sent to: New Bern Amateur Radio Club, Inc., P.O. Box 2483, New Bern, NC 28560. Certificate depicting "The Swiss Bear" will be awarded stating that the station has met the requirements for this award.

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NEW products

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Firestik's Speak-Easy mini-speaker is an acoustically tuned, wide-range air compression speaker that's small in size (2¼ × 2 inches) yet offers 300 to 10,000 Hz of audio response for crisp and clean sound. The Speak-Easy speaker is molded in an indoor/outdoor shockproof case and is easily mounted anywhere on cars, trucks, motorcycles, vans, airplanes, or RVs. In addition, it is exceptionally weathertight and resistant to corrosion. Mechanical features include a pulse dissipating disk, grill filter, a half-inch voice coil and a 1¾-inch magnet. Every Speak-Easy speaker comes complete with a 6½-inch coaxial cord with a 3.5 mm plug, fully adjustable mounting bracket, and hardware for quick and easy installation. For more information on this new product, write to Firestik Antenna Company, 2614 East Adams, Phoenix, Arizona 85034.

BASIC coding form

The Pocket-BASIC Coding Form by ARCsoft Publishers simplifies writing programs for the TRS-80 pocket computer. It's available in 50-sheet or 100-sheet pads and makes clear the relationship of overlapping memory locations such as A, A$, A(01), and A$(01).

Pocket-BASIC Coding Form displays the computer's fixed memories side-by-side with a large area for listing their contents. It also gives plenty of space for the programmer to label and list his flexible memories. The face of the form has space for program title, programmer's name, date, and page number plus ample room for special notes and comments.

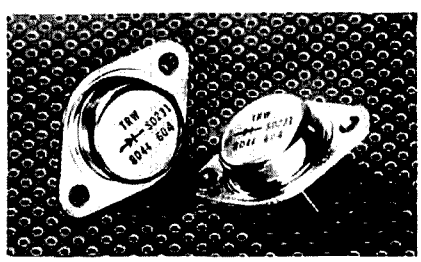
The reverse of the 8½ × 11 inch form is precision-ruled for thirty horizontal program lines, each divided by eighty vertical columns. Program lines are numbered in standard 10-300 line numbers in the margin for spotting at a glance. Vertical columns, left to right across the 11-inch width of the sheet, are numbered 1-80 for easy identification of available spaces in a standard TRS-80 pocket computer input memory. A program using all available steps and memories can be listed on the form's thirty lines by packing for maximum efficiency. Using shorter line contents, a very elaborate program can be listed on two sheets from a pad. The form can be used with any computer in the BASIC language.

Pads are available from ARCsoft Publishers, P.O. Box 132E, Woodsboro, Maryland 21798. Pads of fifty sheets sell for $2.95 plus $1.00 postage; pads of one hundred sheets sell for $3.95 plus $1.00 postage.

dual Schottkys

Two dual-power Schottky diodes that require no snubber networks have been introduced by TRW Power Semiconductors. The SD-231 and SD-232 diodes are dual diode versions of TRW's recently introduced SD-31 and SD-32 Schottky diodes. All four devices are high-voltage 30-amp diodes with a junction temperature rating of 175°C, which TRW says is higher than any comparable Schottky device.

The SD-231 is rated at 60 V_{RMM}, the SD-232 at 50 V_{RMM}. Both are housed in a TO-204MA package (formerly TO-3), and both are designed for rectification and commutation in high-current 5-volt logic supplies in military or industrial use. The two new diodes achieve avalanche protection with a shunt P-N diode, which is formed in addition to the Schottky barrier. This P-N diode breaks down at a lower voltage than the Schottky diode. But because the current is more evenly distributed along the P-N junction, large amounts of reverse energy can be tolerated. It is this ability to withstand high reverse energy, along with the devices' high voltage rating, that permit the SD-231/SD-232 dual diodes to be operated without the snubber networks previously required to protect Schottkys from avalanching.



In 100s, the SD-231 diode costs $8.81 and the SD-232 diode costs $7.95. Delivery is six to eight weeks. For further information, including data sheets, contact John Power, TRW Power Semiconductors, 14520 Aviation Boulevard, Lawndale, California 90260.

micro-miniature sub-audible tone encoder

Trans Com, Inc., introduces the new micro-miniature 401 sub-audible tone encoder. Measuring only 1.0 × 0.6 × 0.3 inch, the encoder can be installed in radios where other similar types of encoders cannot. The 401 has an operating range of 7 to 20 volts with a current consumption of only 4 mA. It is fully tunable from 67 Hz to 251 Hz and has an excellent temperature stability over a broad temperature range. Its features include compatibility with PL, CG and other CTCSS tone systems; small size; operating voltage 7-16 Vdc reverse polarity protected; operating current 4 mA, 12 Vdc; adjustable tone level 0 to 2 VPP; and low tone distortion, less than 1 percent THD. The tone stability is ±0.2 percent Hz from −20°C to +70°C, and there is a two-year warranty. Contact Trans Com, Inc., 1104A Ridge Avenue, Lombard, Illinois 60148.

1981 Radio Shack catalog

Radio Shack's new 176-page 1981 catalog is now available, free on request, from more than 6,000 participating stores and dealers nationwide. The catalog has 120 full-color pages and features the latest in everything electronic from computers and stereo components to toys and electronic games, parts, and accessories for home entertainment hobbyists and experimenters.

Among the products being offered for the first time are the TRS-80 Pocket Computer; the TRS-80 Color Computer; the TRS-80 Model III Desk-Top Computer; six new stereo receivers, two with digital quartz tuning; and five stereo cassette tape decks featuring Dolby noise-reduction circuits.

The new catalog includes the TRS-80 line of microcomputers, Realistic stereo components, CB equipment, radios, tape recorders, thirteen new electronic calculators, six digital clocks, seventeen electronic games, Archer antennas, Micronta test instruments, and ArcherKit and Science Fair hobby kits.

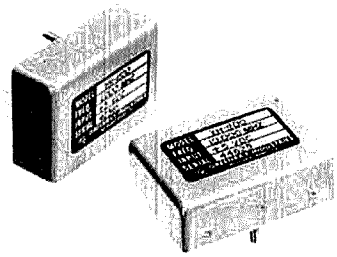
For further information contact Tandy Corporation/Radio Shack, 1800 One Tandy Center, Fort Worth, Texas 76102.

medium power Darlingtons by Motorola

Motorola has announced a new series of complementary TO-92 Darlington transistors, designed specifically for preamplifier applications requiring a high dc current gain and an input impedance of several megohms. The low-cost, plastic-packaged transistors are available with breakdown voltage ratings of 40, 50, and 60 volts, a dc current gain of 10,000, and excellent current-gain linearity from 1 mA to 100 mA. Contact Motorola Semiconductor Products, Inc., P.O. Box 20912, Phoenix, Arizona 85036.

miniature frequency standard

The model YH-1100 miniature frequency standard provides specified output frequency in the range of 1 MHz - 60 MHz. Although measuring only 4.5 cubic inches (73.7 cc), the unit can provide a frequency stability of $\pm 5 \times 10^{-8}$ per day. With an output that will drive up to 10 TTL loads, and operating from a single 5 Vdc input, it is ideal for digital applications where size and stability are critical.



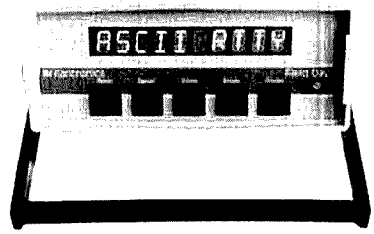
The price is $175.00 for 100-unit quantities, with some common frequencies from stock.

For further information, write Greenray Industries, Inc., 840 West Church Road, Mechanicsburg, Pennsylvania 17055.

H.H. Smith catalog

Herman H. Smith, Inc., of Brooklyn, New York, is making available its newly published Catalog 810 for design engineers and purchasing agents. The recently produced, 100-page, full-line catalog features a number of new products, including the recently developed "safety engineered" test lead package, which permits the user to assemble complete test lead systems from standard shelf items to retrofit with existing and new equipment. These include prods, meter inputs, input adapters, and cables with connectors. Other new items offered in Smith's Catalog 810 are an extended group of printed circuit board supports, flat wire cable clamps, and many new spacer types, including 3/16-inch O.D., 1/4-inch

Code reading makes ham radio more fun!



Field Day 2

A code reader can add to the fun of ham radio by allowing you to copy many signals that are too complex or too fast to decode by ear.

You can get in on such things as news-wire service transmissions, weather information and financial reports that are sent by radioteletype (RTTY), ASCII computer language or Morse code.

Some code readers only copy one or two types of signals, but the **Kantronics Field Day 2** ™ allows you to copy RTTY at 60, 67, 75 and 100 WPM Baud, ASCII at 110 and 300 (if sent as it is typed) WPM Baud and Morse at 3 to 80 WPM.

The **Field Day 2** even has an editing program to improve sloppy Morse. You get more of the message and fewer illegal character signs than with other code readers. With a **Field Day 2** you also get a 24-hour clock, code speed display and TTL compatible demodulator output.

The **Field Day 2** is a complete unit in one package with a large, easy-to-read, 10-character display and is backed with a full-year limited warranty.

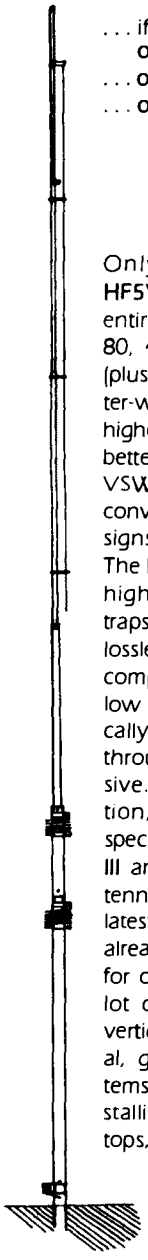
Code reading makes ham radio more fun, and now you can get started with one compact, versatile unit, at $449.95, suggested price, the **Field Day 2.**

Call or visit your Authorized Kantronics Dealer for a demonstration!

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(913) 842-7745
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WHY PAY

FULL PRICE FOR AN 80-10 METER VERTICAL



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Only Butternut's new HF5V-III lets you use the entire 26-foot radiator on 80, 40, 20 and 10 meters (plus a full unloaded quarter-wavelength on 15) for higher radiation resistance, better efficiency and greater VSWR bandwidth than conventional multi-trap designs of comparable size. The HF5V-III uses only two high-Q L-C circuits (not traps!) and one practically lossless linear decoupler for completely automatic and low VSWR resonance (typically below 1.5:1) on 80 through 10 meters, inclusive. For further information, including complete specifications on the HF5V-III and other Butternut antenna products, ask for our latest free catalog. If you've already "gone vertical," ask for one anyway. There's a lot of information about vertical antennas in general, ground and radial systems, plus helpful tips on installing verticals on rooftops, on mobile homes, etc.

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Herman H. Smith, Inc., produces more than 20,000 electronics components and hardware at its main plant and maintains conveniently located regional warehouses which supply major industrial electronic distributors and OEM users in the U.S. and Canada. Contact H.H. Smith, Inc., 812 Snediker Avenue, Brooklyn, New York 11207.

soldering iron stand

Wahl Clipper Corporation, manufacturers of the complete line of ISO-TIP brand soldering irons, has introduced a new "double-duty" soldering iron stand. The new stand is a combination soldering iron stand and caddy. When closed, the stand contains the soldering iron shaft and tip within the closed metal compartment, thus allowing an iron that has not yet completely cooled down to be placed in a tool box or caddy without damage to adjacent components. The compact, durable, yet lightweight soldering iron stand/caddy also protects the shaft and tip from possible damage in transit.

In the "open" position, the stand functions as a standard soldering iron stand, holding the iron within easy reach between uses. The stand also features a tip wiping sponge and well. For further information, contact Clipper Corporation, Sterling, Illinois 61081.

COAX-SEAL for protecting connectors

Keep the name COAX-SEAL in mind the next time you need a means to keep moisture and corrosion out of your coax fittings. It's not too often a new product line crosses our desk that has caused as much excitement as this one. One wonders why COAX-SEAL hasn't appeared sooner. It has been used commercially for eight years and is just now finding its way into the Amateur market.

COAX-SEAL is a pliable, plastic material that can be wound over coax fittings of any size or shape then handmolded to give a long-lasting, flexible waterproof and dustproof seal. This new material stays flexible at temperatures from −25 to 350 F (−32 to 176.8 C).

COAX-SEAL maintains its sealing qualities regardless of movement of the coax. It also adheres to polyvinyl or vinyl outer coax jackets. The material allows quick decoupling of a coax fitting and also re-sealing of the fitting using the same material. Application is by hand — simply roll off approximately 6 inches (15 cm) of COAX-SEAL, remove backing paper, wrap starting at outer covering and work toward fitting, allowing a one-half overlap as you go. After the wrap is completed, gently knead to form a smooth surface and to force out any air.

COAX-SEAL comes in rolls, 60 inches (152 cm) long, 1/8 inch (3 mm) thick and 1/2 inch (13 mm) wide on backing paper. For more information, contact Universal Electronics, Inc., 1280 Aida Drive, Reynoldsburg, Ohio 43068.

dummy load

The new Ten-Tec Model 209 air-cooled rf dummy load is an excellent accessory for the ham shack or test bench. It allows transmitter operation for testing or alignment without disturbance to other Amateurs on the air.

Model 209 is rated at 300 watts for 30 seconds with derating curve for extended use. VSWR is 1.1:1 maximum from 0-30 MHz, 1.5:1 maximum for 30-150 MHz. The dummy load is housed in a perforated aluminum enclosure, dark painted for excellent heat dissipation. SO-239 connector is built-in for convenient installation. Price is $26.00. Contact Ten-Tec, Highway 411, East Sevierville, Tennessee 37862.

1021 DTMF receiver

The 1021 DTMF receiver is designed to detect and decode the six-

teen standard tones used for Touch Tone dialing. By *incorporating* the latest in technology it is possible to have a high-quality DTMF receiver measuring only 3.5 × 1.9 × 0.4 inch. The 1021 features low current consumption, typically 4 mA at 5 Vdc. The 1021 DTMF receiver consists of dual bandpass filters, dial tone rejector filter and limiters, a DTMF decoder with latched binary outputs, and a four to sixteen line converter. The input signal can vary from a level −30 dBm to 0 dBm with a digit detection time as short as 20 milliseconds. The four-bit binary and strobe outputs are provided through a five-pin header on the card; power and the sixteen discrete lines are available through a 25-pin connector with 0.1-inch spacing. When a digit is decoded, the strobe and digit line goes high for the duration of the tones detected. The binary outputs are normally set for 20 milliseconds, but can be lengthened. Both the filter and decoding circuits are crystal controlled for long term stability and accuracy. Contact Trans Com, Inc., 1104A Ridge Avenue, Lombard, Illinois 60148.

nick-free wire stripper

O.K. Machine and Tool introduces a new, all-purpose, manual wire stripper, the ST-300. It has a convenient adjustable stop for consistency in wire strip lengths. This easy-to-use tool strips 14 to 22 AWG solid and stranded wire cleanly and quickly. It strips Kynar, vinyl, polyethylene, rubber, neoprene, and irradiated vinyls — almost all insulation materials in use today. With one light squeeze of the handles, cutting blades cut through and remove up to ¾ inch of insulation. Heavy duty and reliable, the tool is ideal for appliance, automotive, electrical fixture, instrumentation and household wiring. The ST-300 won't damage or nick wire. Available from stock for $9.95 from your local electronics distributor or directly from O.K. Machine and Tool Corporation, 3455 Conner Street, Bronx, New York 10475.

short circuit

optional sidetone

Those who are confused as to how to incorporate the optional sidetone into the CW keyboard program for the Apple II computer (October, 1980, *ham radio*) may find the following of interest. It is a program change for the addition of optional sidetone.

1. Enter monitor with CALL -151 or press RESET. (* cursor).
2. Type 3ØA: AD 3Ø CØ 88 DØ F5 AD 58 CØ 6Ø.
3. Press RETURN.
4. Re-enter BASIC (CTRL C).
5. In both lines 5 and 6, change the number 774 to 772.
6. Delete Line 620 (DEL 620).

To delete the sidetone, merely rerun the program. **Steps** 1-4, however, must be repeated each time the sidetone option is to be used unless the poke statements in lines 18 to 23 are changed, starting at :POKE 778,173, in line 18.

Although left as an exercise, here's a hint for converting hexadecimal numbers to decimal: For a three-digit hex number, multiply the first digit by 16^2. Add (second digit × 16) plus third digit.

For a two-digit number, multiply the first by 16, add the second. Example: Convert $3A7 to decimal. On the Apple keyboard, type: PRINT 3*16↑2+10*16+7. (=935).

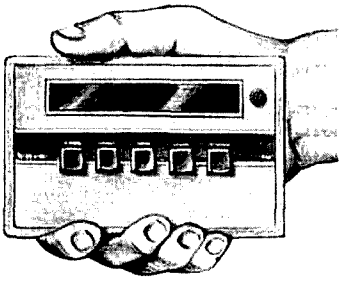
Modifications in **steps 5** and 6 are a permanent part of program, with or without sidetone.

contributed by
Bill Skeen, W6WR

updating the HW-2036

Those who would like a copy of the reverse side of the printed circuit boards in fig. 9 (page 55) of WA4BZP's article in the November, 1980, issue of *ham radio* may obtain one by sending a stamped, self-addressed envelope to *ham radio*, Greenville, NH 03048.

Copy RTTY, ASCII and Morse from the palm of your hand.



Have you waited to get into code reading until you found out what this latest fad was about? You can stop waiting, because it's no longer a fad.

Amateurs everywhere are tossing the gigantic clanking monsters of yesteryear that once performed the job of reading radioteletype. They are trading them in for state-of-the-art code-reading devices that are incredibly small, noiseless if desired and infinitely more versatile than their antique predecessors.

Kantronics, the leader in code-reading development, has just introduced the latest and most-advanced breakthrough in the copying of Morse code, radioteletype and ASCII computer language.

The **Kantronics Mini-Reader** reads all three types of code, displays code speed, keeps a 24-hour clock, acts as a radioteletype demodulator and reads all of its decoded information out on a traveling display of 10 easy-to-read characters. It is so compact that it fits in a hand-held, calculator-size enclosure.

At $314.95, the **Mini-Reader** outperforms anything within another $400 of its price range.

Call or visit your Authorized Kantronics Dealer now to find out what the latest in technology has done to code-reading.

Kantronics
(913) 842-7745
1202 E. 23rd Street
Lawrence, Kansas 66044

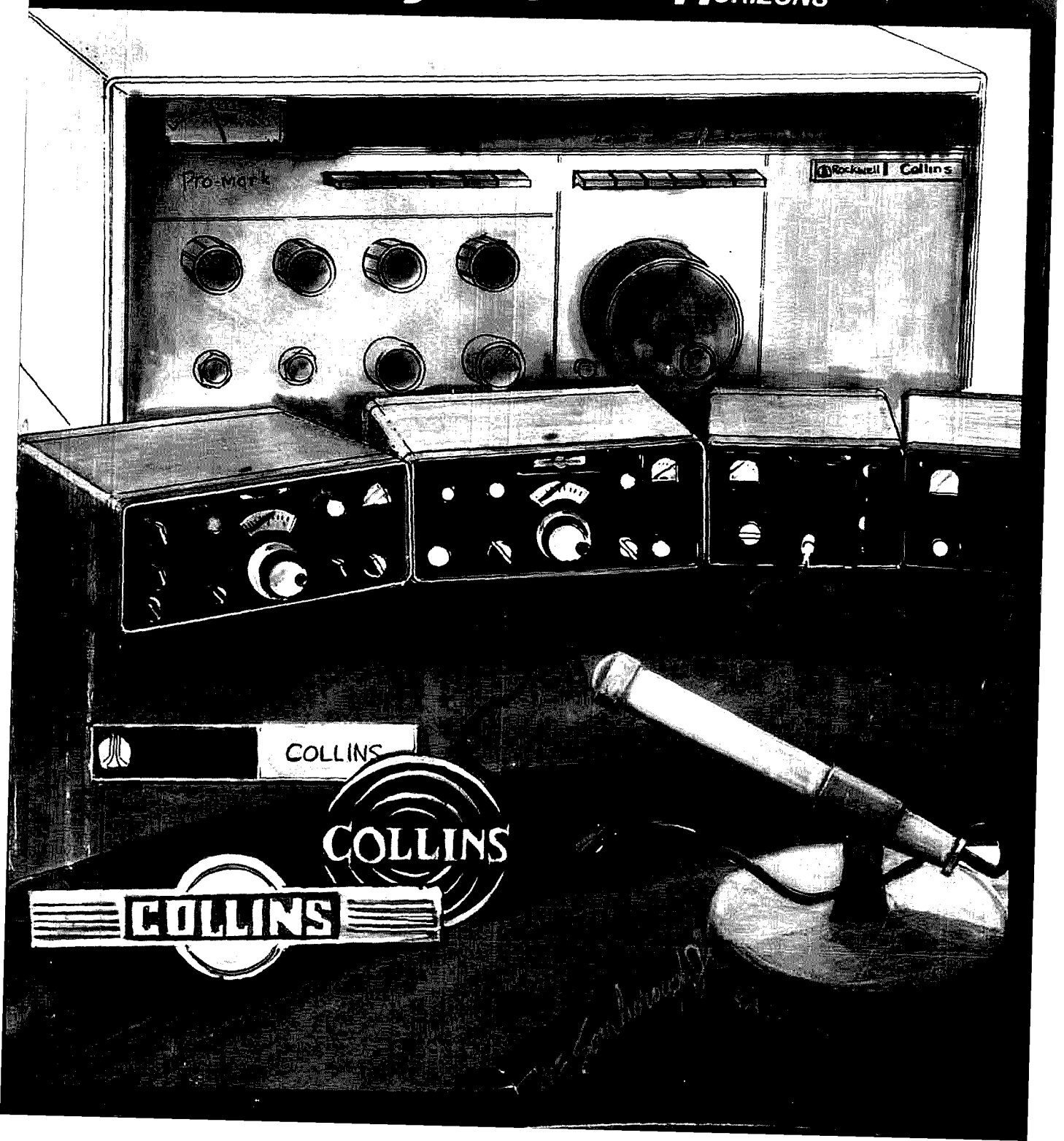
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APRIL 1981 / $2.50

S-LINE OWNERS REPORT



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APRIL 1981

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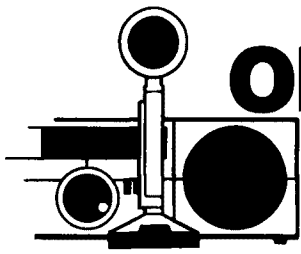
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Observation & Opinion

It's getting to be that time again. The end of a long winter. The ground is beginning to thaw. Trees are starting to green up. Time to start thinking about antennas. And here I am, a displaced Californian, in the incredibly beautiful part of the country known as New Hampshire. In California I'd had to contend with problems such as zoning ordinances, a small city lot, and neighbors with marginal TV and stereo sets and a suspicious attitude toward ham radio operators.

But now, after some 45 years of hamming, suddenly it's different. I have some freedom: a location miles from the nearest city, rolling green hills sloping toward a huge lake, no maze of high-voltage wires, no manmade interference. This spring I'll put up the ideal antenna.

But what's the "ideal" antenna? After reading Jim Lawson's series in *ham radio*, one might consider the Yagi beam to be the ideal antenna. But to perform well, the Yagi requires, among other things, a tower of substantial height. This means bucks. Or, one might consider the quad antenna (also bucks and problems with construction).

So, I have decided that the ideal antenna for me is the long wire. It requires *lots* of wire and *lots* of real estate. But I'm fortunate. I have plenty of room for installation and a reel of surplus annunciator wire — enough for ten wavelengths on the 20-meter band. According to the technical literature, a wire ten wavelengths long will produce a gain of 7.5 dB over a dipole, a very respectable figure indeed.

OK, you say, how do you rotate it or change its direction for DX? Answer: you don't. If the antenna is long enough and pointed in the general direction of the highest concentration of the foreign Amateur population, the long wire will not only provide excellent DX results off both ends, but will also produce sidelobes that will cover intermediate directions.

This theory was proved last summer, when I first erected a long wire soon after arriving in New Hampshire. That long wire was only about three wavelengths on 20 meters. It was oriented due north and south; the low end of the antenna was only about 25 feet above ground. With low power (10 to 15 watts) I worked everything I could hear on 20 meters, both on short and long path. The long-path openings were few but produced some excellent contacts.

So this spring I'll put up a long wire, ten wavelengths long, on 20 meters, running north and south, and I'll feed it with the legal maximum power. Some muscles will be required to get it up into the trees (I'll enlist the aid of my staff). Watch out, Bob Locher! I'm out to give you the business!

The end of this month brings the ever-popular Dayton Hamvention. It will be interesting to see how this year's show turns out. Despite sounds of doom and gloom expressed by some in the industry, there are signs of hope. I hear rumors that several manufacturers are planning to announce new product lines at the show. That should be something to look forward to. The fact that almost all of the major names in Amateur Radio will be at Dayton should make for an enthusiastic crowd.

This will be the first year I've had a chance to visit the Dayton show. In all my years with *ham radio* I've been living on the West Coast and couldn't attend. But this year I'll be at Dayton with an open mind and megabytes of memory storage. I want to talk to *you*, our reader, to get your feelings about the new *ham radio*: what you like and dislike about it; what you'd like to see in it. I want to talk to industry leaders, look for new authors, try to find a few bargains in the flea market (more antenna wire), and just rap. Dayton will be extremely important to me as editor of *ham radio*; but it will be more important to *you*, our readers. Because you can tell me what you want to see in issues to come.

Look me up. I'll be there to listen to you. We need you and you need us. See you at Dayton!

Alf Wilson, W6NIF
editor



comments

Dear HR:

Several things are distressing about buying and selling the answers to the Amateur license examinations, as you mention in your December editorial. I hope the matter will eventually be settled by having the FCC copyright its future Amateur tests. I hate to see Mr. Bash get rich and famous when the main thing that attracts anybody to "his" stuff is precisely the fact that he didn't write it! He only compounds his dishonesty by posing as a rebel voice against the stingy, oppressive Federal regulators — it's all a sales pitch.

But even you somehow seem to react as if an easy way out were being offered. Anybody who buys on this assumption is begging to be taken advantage of, since memorizing answers is actually the single most difficult way to prepare for a technical examination. The only way to make it easy is to learn to understand the subject matter, surely not an unfair requirement for a radio operator's license.

I myself took up Amateur Radio in 1979 and now have my Extra class license, yet I'm no electronics expert — only an interested student who isn't afraid of a multiple-choice examination. In my opinion, Bash and his supporters are treating our whole tradition of self-training — one of the best things about this hobby — with scorn.

David Satz, N1AWG
Cambridge, Massachusetts

Dear HR:

W6SAI's article in the September, 1979, issue of *ham radio* concerning problems with the Collins KWM-2 transceiver was helpful to me in curing relay problems with my 32S-1 transmitter. The power relay, K1, would sometimes trip as soon as the tubes warmed up, causing the transmitter to turn on. But frequently K1 would not turn on hard enough to trip the antenna relay, K2. It seemed to me this problem was brought about by stray rf tripping the VOX relay actuator tube, VIIA, a 6U8A.

After examining the circuit carefully, I decided to shield R75, the grid resistor of VOX amplifier tube, V14A, a 12AT7. I felt this resistor might be developing a current from stray rf and feeding the amplifier. Next, following W6SAI's suggestion, I installed a 2-watt, 4700-ohm resistor between pin 1 (plate) of VOX relay actuator tube VIIA and K1. Finally, I replaced the two 68k 2-watt resistors composing R89 in the cathode circuit of VIIA with three 100k, 2-watt resistors, because the other resistors had shown signs of overheating.

These modifications seem to have completely cured my 32S-1 of relay trouble, and I thought they might be of interest to others who operate Collins S-line equipment.

Frisco Roberts, K5CE
Corpus Christi, Texas

Dear HR:

This letter concerns an article in *ham radio* entitled "Navigational Aid for Small-Boat Operators" by Henry Keen, (September, 1980, pages 46-47).

While we appreciate Mr. Keen's effort to provide information regarding navigational aids for boaters, we are concerned that the system described would be in violation of the Commission's rules. For example, Mr. Keen states in the last paragraph of his article, "I suspect that such a system might operate, for example, in one of the 20-kHz slots that appear in the CB spectrum." We do not feel that this would be possible or advisable for the following reasons.

Specifically, the proposed use of two beacon transmitters would not be in accordance with Section 95.401, Rule 22(a) of the Citizens Band Radio Service Rules which limit CB communications to telephone only. In addition, Rule 23(a)(4) of the same section forbids the transmission of one-way communications by a CB station. Further, Mr. Keen's reference to the involvement of a marine operator raises other questions regarding operator qualifications and equipment control. We also should add that while Mr. Keen is a licensed Amateur, his proposed system would not be licensable in the Amateur Radio Service. Nor do we know of any other Commission service which could license the suggested navigational aid as proposed.

We are bringing this information to your attention so that you may alert your readers to the regulatory difficulties involved in the proposed system and to warn them against purchasing radio equipment that is not licensable.

Robert L. Cutts, Chief
Spectrum Management Division
Federal Communications Commission
Washington, D.C.

Dear HR:

To an old-timer who used loop modulation on 10 meters in 1932 and learned fm during World War II under Fred Budleman and Fred Link (Link Radio Co.), the article on amplitude compandored sideband (ACSB) is nothing short of exciting. But can't we find a better name for it?

Am and fm are short, descriptive titles. SSB, or better, SB, or *sideband*, have a nice ring. NBVM is as cumbersome as the implementation of the technique. With full apologies to Dr. Lusignan, "amplitude compandored sideband (ACSB)," has zero appeal. Furthermore, it omits an important part of the technique: the pilot tone.

A more descriptive, easier-to-handle title is compressed piloted sideband (CPS). This might be shortened to compiloted sideband modulator (CSM). Let's start the new baby off with a good name.

Jack Geist, N3BEK
Silver Spring, Maryland

presstop

ARRL WILL DISCOURAGE 18 AND 24 MHZ "experimental" or beacon operation by U.S. Amateurs, the League's Executive Committee agreed recently. A number of Amateurs have applied to the FCC for Special Temporary Authorization to transmit on the two future Amateur bands, as is being done by the two Canadians who are working on 10 MHz. But with the uncertainty about when either 18 or 24 MHz will become available, it was felt that any such preliminary Amateur operations would encourage others without STAs to follow suit. The negative reaction that such unauthorized operations could generate, it was felt, would more than outweigh any possible benefit.

AMATEURS OPERATING 420-450 MHZ in the vicinity of military installations in the Southwest and Florida got a nice break from the FCC at its agenda meeting on February 11. Acting on a petition from AMSAT to permit a power increase from the present 50 watts DC input in those areas, the Commissioners decided, with the agreement of the Air Force, that an increase to 1000 watts EIRP was acceptable. There is a stipulation, however, that the transmitting antenna be directed at least 10 degrees above the horizon. In addition two new restricted areas, both of 50 miles radius, were added at Otis Air Force Base in Massachusetts and Beale Air Force Base in California. Other restricted areas are described in Part 97.61(b)(7) of the rules.

HMR COMMUNICATIONS IS BEING SUED for $150,000 by the Commonwealth of Pennsylvania in a suit filed February 18. In a news release, the state said HMR and its officers, Henry M. Robbins, Jr., and Sr., and Alice B. Robbins, "have repeatedly and continuously violated provisions of the state unfair trade practice and consumer protection law." Specific charges include representing HMR as a "million dollar" electronics company when in reality it is literally a "garage" operation. "HMR has misrepresented the nature and number of its customers, its size and assets, the names and qualifications of personnel, quality of equipment, delivery time, terms and conditions of sale, and warranty provisions." The state's Bureau of Consumer Protection says it has evidence that the Robbinses have not acted in the interest of the corporation but rather in their own personal interest in their dealings.

The Suit Asks the Westmoreland County Common Pleas Court to order HMR and the Robbinses to make restitution to all of the more than a dozen complainants, plus pay the state a civil penalty of $150,000.

FCC'S NEW FORM 610 IS CAUSING enough Amateurs problems that a significant number of the forms are being returned without action. Principal confusion with the August, 1980, version (the only one now valid) is with questions 2A-2J: 2A should be checked only if there are no changes, 2G only if there is any change in name, such as dropping "Jr." (the former name must also be provided), and 2H and/or 2I, which must be checked if the mailing address or station location are changed. Questions 3 through 17 must also be answered, and failure to include the original or a photocopy of the license is also bouncing a number of applications.

A BIZARRE MURDER ON PALMYRA that took place during the 1974 KP6KR Kingman Reef DXpedition and involved the DXpedition group has just come to light in Hawaii. A young couple had run aground off Palmyra and were helped ashore by the DXers before they moved on to Kingman. An older retired couple, the Johnsons, arrived at Palmyra while KP6KR was operating on nearby Kingman and then disappeared without a trace.

A Month Later The Young Couple arrived in Hawaii on Johnson's yacht, repainted with no registration numbers. They were arrested, tried and convicted of piracy and related charges—but not murder, as no trace of the Johnsons was found. WA9UCE (now N6RJ) testified for the prosecution at their trial.

The Johnsons' Bodies have now turned up in a drum in Palmyra's lagoon. On February 23, the convicted pirates were indicted for murder.

FCC WILL CERTAINLY SUFFER as a result of expected governmental austerity under the Reagan administration. The Commission has been told by the Office of Management and Budget to expect to cut permanent positions by 8%, with 5% to go this year and 3% more in fiscal 1982. According to Broadcasting magazine, that amounts to a staff reduction of 160. Just where in the FCC those people will come from remains to be seen, although it's almost certain to affect Amateur Radio matters.

220 MHZ WAS SPARED, but the Commissioners did give 216-220 MHz to the proposed automated inland waterways communications systems (IWCS). The initial proposal for IWCS had triggered protests from the Amateur community when a purported typographical error specified 216-225 MHz as one of the options for the new system.

In An Unusual Move, the Commission adopted only those technical standards for IWCS that would serve to protect adjacent TV channel 13. Actual operational standards are to be proposed by potential IWCS users and suppliers.

Collins Owners' Reports:

the S-line

A survey of owners' opinions on the Collins 32S-line transmitter and 75S-line receiver

In April of 1980, *ham radio* magazine published a questionnaire directed at the owners of Collins radios: the KWM-2/2A transceiver, the 32S-line transmitter, and the 75S-line receiver. The results of the transceiver portion of that questionnaire were printed in the March issue. This month, we are presenting our findings on the 32S and 75S transmitter/receiver pair, based on the 210 completed questionnaires received.

the good features

Like the reports we received on the KWM-2/2A, reports on Collins S-line gear have been overwhelmingly favorable. For example, 74 percent of those surveyed rated Quality of Workmanship a 10 on a scale of 1 through 10. That's an astonishing figure. Also ranking very high were Durability, which received a rating of 10 from 70 percent of those who replied, and Reliability, which was rated 10 by 65 percent of the respondents to our survey.

Other features of the Collins S-line praised by many S-line owners were stability, audio quality, ease of maintenance, receiver selectivity, and dial accuracy. See **table 1** for the full story. It's clear that these solid and dependable Collins radios are highly thought of by the hams who own them, and that they have retained their reputation for quality down through the years despite all of the technological wonders that have come along since these radios were first designed. Here are some of the comments we received to the question, What is the rig's best feature?

table 1. What is the rig's best feature?*

	percent
Reliability	45
Stability	27.5
Receiver performance	17.5
Dial accuracy	15
Clear audio	15
Selectivity	12.5
Signal quality	12.5
Ease of maintenance	12
200-Hz CW filter	11
Ease of tuning	10
Durability	8.5
Sensitivity	8.5
Wide frequency coverage	7.5
Resale value	5
Service manual	3
No TVI	2.5

*Many respondents gave more than one response.

By Martin Hanft, WB1CHQ, Production Editor, *ham radio* magazine

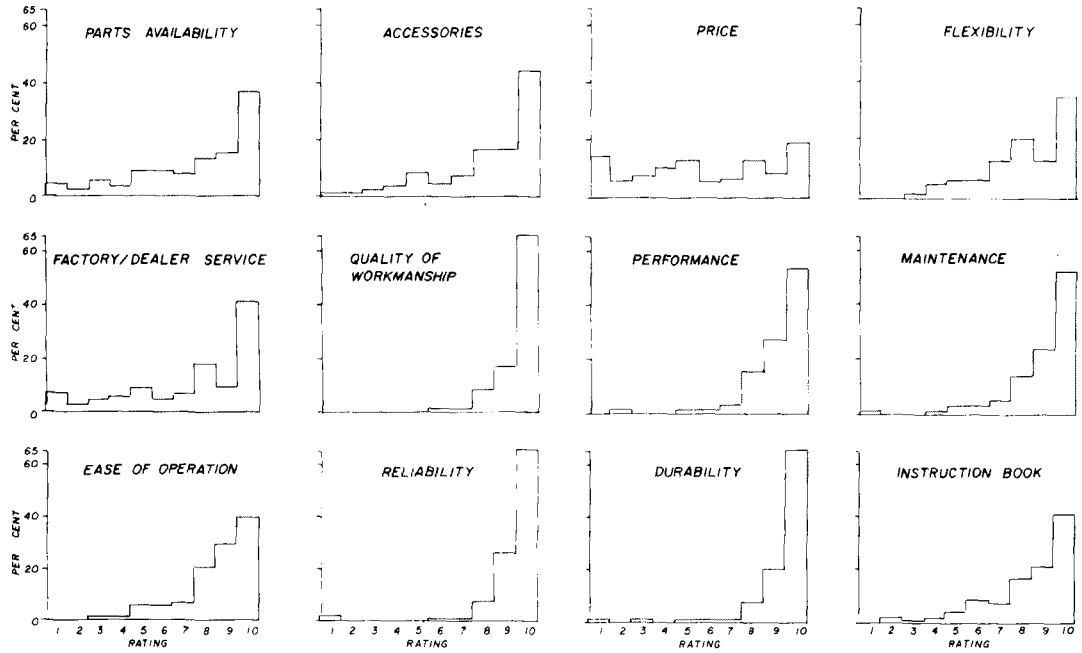


fig. 1. Ratings of the S-line transmitter/receiver pair, from 1 (poor) to 10 (perfect).

"Wide frequency coverage for MARS, easy to operate, and very reliable." — W3PE

"Receiver is top of list when peaked and holds up over long periods of use. There's very little aging of components. Signals may be equaled but not beaten in quality." — W5CAE

"Total reliability under adverse conditions, ease of service, dial accuracy and stability of both frequency and operation. Also the ability to cover frequencies between 3.2 and 30 MHz without modification — or trading it in for another rig!" — W5USI

"Day in and day out reliability." — WA6T

"Outstanding sensitivity on all bands, and it does not have the constant hiss of solid-state receivers. Crisp audio (no mush)." — K6ITL

"This rig is reliable, no question about it. I expect it to perform every time I turn it on and it does. Also, the inter-connect for transceive operation is a plus." — WDØEOT

"Selectivity and ability to operate without strong signals blocking the receiver. I work 80 and 40 CW the most, and I've yet to find a receiver that can outperform the 75S-3B on these bands." — N2DL

"Excellent receiver and transmitted audio. I have modified my receiver according to Jim Fisk's article about cascading filters. I've also added some solid-state-equivalent "Tubesters" in certain areas: agc, audio, VFO, and crystal calibrator." — VE3UP

"Miles of band spread." — W3EHA

"Ease of operation. Sixteen years old yet it competes favorably with present-day designs. Holds resale value. Minimum upkeep and repair." — W6MIR

"Front-end overload characteristics. It does not give up and die in a strong signal environment, the way the vast majority of current solid-state receivers do. The 200-Hz CW filter is the best I've ever used." — W6JD

"Reliability. But also outstanding for quality construction, frequency stability, and re-set accuracy." — W7AY

"One of the best thought-out designs ever. Extremely stable — clean signal. Does everything it was meant to do, *well*. One of the most maintainable rigs ever. A real classic in my book." — WAØTWH

"Collins uses top-quality switches, making for long, trouble-free life. I have used all of the popular top radios and I still keep coming back to the Collins even though it doesn't have all the fancy features. It can't be beat."

"Does not drift. When I tune in on a certain frequency it stays on that frequency. It has a very good tone. I get good reports from most QSOs. One man even said to me, 'I bet you're using a Collins.' " — WBØJJJ

"The best feature of the S-line has always been its

quality of construction, which has led to a record of reliability and dependability unparalleled in Amateur equipment. It should be borne in mind that the S-line is not, strictly speaking, Amateur equipment, as there are probably more units in government and commercial service than in Amateur use." — WAØFYG

"Reliability, good signal quality, stability." — K9KER

"Overall quality. Good sensitivity and selectivity. Extremely durable and easy to service." — K4NYK

"Never had any trouble with it. Superb workmanship and quality control." — WB7VOR

"Rejection tuning (variable noise blanker)." — KH6BD

"I can tune in WWV on Monday, turn it off and turn it back on on Friday and WWV will still be zero beat." — K4KAE

"Trade-in value." — K9GEL

"A ham could easily become an appliance operator with a rig this well built." — K3JHB

"Dial readout and mechanism, rugged construction, and neat, uncluttered layout." — W1EED

"Highly durable: works 3:1 SWR all day with no problems." — KA6JJK

"I believe that it is impossible to name one feature that is best, but, if I had to, I believe it would be reliability and quality of construction. What other rigs can you name that after twenty years are still state-of-the-art and operational?" — WD8BTU

"Ease of operation, dial accuracy, and consistent power over a wide range of frequencies." — W6DPD

on the other hand

Despite the almost overwhelming praise for the Collins S-line gear, there were also some criticisms. But not many. More than 55 percent of our respondents told us that there are no worst features to the S-line, or if there is one they haven't found it yet. That's quite a recommendation. Others, however, mentioned difficulty of tuning (and the time involved), being limited to 200-kHz tuning, problems with the agc, lack of R.I.T., and the expense of replacement parts. **Table 2** sums up the story.

Here are some sample responses to the question, What is the rig's worst feature?

"Some erratic VOX operation. Hard to change antenna relay." — W3PE

"Use of phono connectors in back for interconnection and accessories results in a rat's nest of cabling and risk of damage by wrong connection." — WA4GWG

"Coverage of only 200 kHz on the VFO dial."

"Can't think of any." — W2MDB ex-1JY

"Price." — W4YY

"S-meter circuit can't hold setting for 10 minutes." — KH6GMM

table 2. What is the rig's worst feature?*

	percent
None	55.5
Use of phone-plug-tipped cables	17
200-kHz tuning	14
Replacement tubes	12
Time spent tuning up	11
No R.I.T.	10
VOX	9
AGC	8
Incomplete coverage 28-30 MHz	7
Not solid state	6
Frequency offset	5
Expense of parts	4
Price	4
Relays	8

*Many respondents gave more than one response.

"Tubes are getting harder to replace." — K9UQN

"Lack of noise blanker." — W6DPD

"Tubes." — N2AQS

"No noise blanker — it is very susceptible to impulse noise interference. Also, tube design is not as sensitive as some of the more modern solid-state designs." — K9AUB

"Can't receive all of 10 meters, even with three plug-in crystals. Poor factory service and availability of parts." — WB6GFJ

"The large number of crystals required to cover the bands." — VE3BGV

"Lack of sensitivity on 10-meter band." — WA5NOM

"High cost of mechanical filters." — K4TTO

"Tubes becoming hard to find." — W5CAE

"None." — WØPEN

"Time required to tune up transmitter." — WA6T

"Servicing is the pits. Invariably, the part you need to get to is buried under six wires, three capacitors, and a big resistor." — WDØEOT

"Retuning transmitter after small amounts of movement within a band." — N2DL

"No R.I.T." — K1MNC

"Lack of ability to receive on the transmitter PTO, no passband tuning, and transceive on CW is not possible because of 1350-kHz offset." — WØYK

"Tunes only 200 kHz." — K1MOU

"Lenghty tune-up procedure when changing bands." — K6MC

"Lack of rf input attenuator in receiver." — W6NTJ

"With this system you have a desk full of equipment and a rat's nest of patch cables behind it. You'd think they'd have a harness for those cables or a mili-

tary-type connector with a dozen or so pins." — WB2MXZ

"Cost." — W5AG

"Cost of parts is much too high. For example, $40 for a spinner knob for the VFO." — WB4DOR

"Unable to use transmitter VFO for receive. Vacuum tubes: heat, size, pi-network final tank circuit, etc. — all those things that go along with vacuum-tube radios." — K4NYK

"The VOX controls are inside the transmitter." — KH6BD

"Lack of R.I.T. function in transceive, power consumption, and heat." — K4KAE

problems

Again, the largest percentage of respondents answered *none* to the question, Have you had any problems? Those that did have problems to report mentioned such things as having to replace capacitors or tubes, TVI, hum, and power supply problems. For the complete rundown, see **table 3**. Below are some of the comments.

table 3. Problems.

	percent
None	43
Tubes	23
Replace small component	13
Ac power supply	5
Relays	5
VOX	4
Alignment	2
Drift	2
AGC	2
Other	1

"VFO in 75S-3C went sour when the receiver was about 1 ½ years old. Linearity was bad (slug changed). I had to buy a rebuilt VFO for $75." — K6RK

"VOX relay draws high current, thus requiring a series resistor. Driver 6CL6 runs hot (it was fixed with a heat-dissipating shield)." — W3DSE

"Dial slipping required some work. Poor contacts on RCA connector. Replaced high-voltage rectifiers and added vent fan." — WB6AJR

"None." — WA7RCR

"VOX on the transmitter and mechanical filter on the receiver." — W6KOM

"Worn dial mechanism (due to use), a bad resistor in the VOX circuit (32S-3), and a bad electrolytic capacitor. All problems well within expectations of the equipment and due to normal use." — K4SE

"Open relay contacts in 32S-3 transmitter require cleaning about every four or five years. Some routine tube failures." — W5AL

"After 19 years of almost daily use a resistor in the VOX circuit failed." — W2VJN

"Minor component and tube failures." — W6GQC

"Bandswitch needed cleaning after exposure to salt water! No other problems." — K6ITL

"Doesn't tolerate SWR over 2:1. Blows out trimmer capacitors in pi-section. Twice replaced rectifier tubes in power supply." — K7AGC

"Band-change switch contacts become corroded in time and require cleaning." — W4YY

"Shorted plate capacitor in amplifier circuit, which caused rectifiers to burn out. Insulation of ac line in transmitter breaking down and shorting." — W6BSO

"Diode in 516F-2 bias supply went bad after one year. Three of the 6U8 tubes became gassy." — WA5NOM

"CW spotting switch causing intermittent in power output. Contacts needed cleaning and adjustment." — K6MBV

"Extreme instability in VOX due partly to heat in R88 and R140 of 32S-3. Audio distortion on 80 meters due to rf feedback into mike circuit." — WB8SRR

"Dial slipping and backlash in 75S-1 receiver PTO. 32S-1 transmitter neutralization sometimes tricky on 10 meters." — WA4GWG

"Defective BFO as received from factory — promptly repaired." — W8IM

"Tube replacement." — K2OB

"The three-section, 40-μFd capacitor in the power supply of the 75S-3B mounts on an aluminum chassis. You can not solder the can to achieve a good ground. This has presented an intermittent hum problem that can be temporarily solved by wiggling the capacitor. Also, have had an intermittent pulling of the receiver VFO. Occasionally, calibration is about 6 kHz low on the VFO dial." — WDØEOT

"Capacitor failure, bad diode, and relay failure." — W3IJ

"Blown resistor in microphone audio switch." — VE3WP

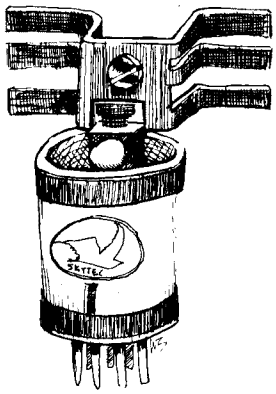
"In the 13 years I have had Collins, I have replaced only one 6146 tube and one small capacitor in the VOX circuit, which I repaired myself. No servicing needed." — WØVUU

"In the seven or eight years that I have owned the S-line and the 15 years that I have owned a 75A-4, other than an occasional tube there have been no component or mechanical failures." — VE3UP

related findings

Table 4 shows the accessories purchased most often by owners of the Collins S-line. Heading the

making your Collins S-line solid state



For more information and a price list, write **SKYTEC**, Box 535, Talmage, California 95481; telephone 707-462-6882.

A large number of Collins S-line owners express concern over the fact that their rigs use tubes. In fact, tube failure was the single largest problem encountered with these radios. Even though problems such as these are easily solved, they are problems nonetheless. For that reason, owners of Collin S-line equipment may be interested to learn about solid-state devices that are now available, devices designed specifically to replace the tubes in the 32S transmitter and 75S receiver with solid-state circuitry.

Each solid-state tube replacement — or Tubester, as they are called — plugs neatly into the socket of the tube it replaces. The Collins 75S receiver will operate completely normally with only one Tubester replacing a tube, or with any mix of Tubesters and tubes, or with all Tubesters. The same is true of the 32S transmitter, except that it is not feasible to replace the driver or power amplifier tubes.

The complete installation and touch-up alignment takes only a few minutes and requires no special tools or test equipment. No modifications need be made in transmitter or receiver, and the installation procedure is simple and clearly explained. Operation and performance of the radios remain essentially unchanged.

Heat reduction is substantial with the use of Tubesters; in the case of the 32S transmitter, there is a 50 percent reduction in wasted power and heat during STANDBY. Reports from owners of Tubesters have been very favorable, and in fact, one of the Amateurs at ham radio *has been using Tubesters for a year and is very happy with them. His only complaint is that, on cold winter nights, he can't warm his hands over the glowing filaments. (Note that Tubesters are designed for S-Line equipment only.)*

list, with a percentage rating of 27, is CW filters. Other items mentioned include crystal pack, linear amplifier, station control, and tuner. Ninety-seven percent of those responding said that they had been able to obtain the accessories they wanted, and an astounding 99 percent were satisfied with the accessories they purchased.

To the question, Have you had the rig serviced?, only 45 percent replied that they'd had service work done, a finding much in keeping with the high score the S-line received for durability and reliability. Of those who did have service work done, 92 percent said the work was satisfactory. To the question, What antenna do you use most?, 59 percent reported that they use a beam. Wire antennas accounted for 33 percent, with all others filling the remaining 8 percent.

table 4. Accessories.

	percent
Filters	27
Amplifier	9
Station control	8
Crystal pack	8
Microphone	7
Wattmeter	7
Tuner	7
Rf processor	6
Q multiplier	5
Phone patch	4

would you buy one again?

To this all-important question, the response was a resounding 80 percent yes, 20 percent no. These figures are even higher than the yes/no ratio for the KWM-2 (73 yes/27 no). Most of those who said that they would not buy the S-line again cited as reasons high price, problems with tubes, and lack of up-to-the-minute, solid-state features. But for each Amateur who would not buy S-line again there were four who would — with no doubt about it. Many owners of Collins equipment are fiercely devoted to their equipment — and to the Collins name. A great number of respondents said that they would own nothing less than Collins.

All in all, it seems safe to say that the Collins S-line and KWM-2 are well liked — very well liked. They are exceptionally reliable and well-built pieces of radio gear that have withstood the test of time and still command a high price. Owners of Collins radios are generally convinced that, for dependability and durability, their equipment is top-of-the-line.

ham radio

high-performance CW filter

Network synthesis provides new applications for surplus toroidal inductors

By Edward E. Wetherhold, W3NQN, Honeywell, Incorporated, Signal Analysis Center, P.O. Box 391, Annapolis, Maryland 21404

Most Radio Amateurs are familiar with the surplus 88- and 44-mH toroidal inductors used as loading coils on the telephone lines. Hundreds of these inductors are contained in cylindrical steel "loading pots" that can be seen mounted on telephone poles along suburban and country roads. These loading pots vary in diameter from 8 to 16 inches (20 to 40 cm) and in length from 1.6 to 6.6 feet (0.5 to 2 meters). Occasionally, after repairing or scrapping a length of line, the telephone company discards these loading pots when they can't be salvaged for re-use.

background

Enterprising Amateurs are sometimes able to obtain these surplus loading pots and remove the inductors for use in audio-frequency filtering applications. During the past fifteen years, these inductors have found their way into many audio-filtering applications such as CW, speech and RTTY filters. A partial list of published articles illustrates the many ways in which these surplus inductors have been used by the Radio Amateur (references 1-13).

During the same fifteen-year period, observant Amateurs have seen the network synthesis method of filter design gradually replace the image-parameter design procedure developed by Otto Zobel in 1923. Filter designs are now possible which previously were not available. For example, the image-param-

eter design procedure requires the addition of *m*-derived matching sections at each end of a prototype pi or T-intermediate section. These matching sections are required to transform the image impedance of the prototype network to a form that can be terminated with a common resistor. In addition to providing a suitable means of terminating the filter, the matching sections also produce a desirable abrupt rise in attenuation, with an attenuation peak at a frequency equal to 1.25 times the cut-off frequency of the prototype section (for $m = 0.6$).

For non-stringent filtering applications, however, the image parameter filter is unnecessarily complex. For example, there are many applications where an increase in attenuation of between 6 and 8 dB per octave for each element is sufficient. With the development of network synthesis, it's now possible to design simple lowpass (or highpass) filters having a simple ladder configuration of alternating shunt Cs and series Ls for the lowpass configuration (or vice-versa for the highpass configuration) that can be terminated directly in resistors without the need for special end-matching sections. The Butterworth and Chebyshev designs are examples of this filter type, and they are frequently used when ease of construction is of prime importance (see references 14, 15, and 19).

By combining the use of these high-quality surplus toroidal inductors with modern filter design techniques, it's possible to build high-performance passive LC audio filters that once were unattractive because of high cost, or the difficulty of design and construction. This article discusses the design and construction of a CW filter using eleven of the surplus toroidal inductors. The filter is easy to build, and its performance is comparable to that of many of the expensive active filters currently available.

loading inductor types and descriptions

Every loading inductor, regardless of type, has two separate and equal windings wound on a molybdenum-permalloy toroidal core with an outside diameter of about 1 inch (2.5 cm). Depending on the inductor type and the connection of the two windings, four different values of inductance are available. The most commonly available inductor has 88 mH in the series-aiding connection and 22 mH in the parallel-aiding connection. (Remember that when doubling the turns of an inductor the inductance is quadrupled, because inductance varies as the square of the number of turns. Thus, by connecting the two windings together in series-aiding, the turns are doubled, and the inductance is approximately quadrupled.) Because the magnetic coupling between the two separate windings of the inductor is not perfect, the inductance in the series-aiding connection is slightly less than 88 mH. A typical measured value is 85.7 mH. This value will be used in the filter design to be discussed. The less-common type has an inductance of 44 and 11 mH in the series and parallel connections.

These 88- and 44-mH inductors are found in at least two different forms. One form is an unpotted stack of five inductors encased in a cardboard or sheet-metal cylindrical case, with a terminal board along its length to which all the inductor windings are connected (see reference 5 for details). These inductors can be easily removed from the stack by prying open the case and cutting loose the leads from the terminal board. Because the inductors are unpotted, any number of turns can be added or removed to obtain any odd inductance value that might be required for a particular filter design. This capability of obtaining a particular inductance value is necessary when the filter cut-off frequency and termination resistance must be a specific value, for example 750 Hz and 600 ohms.

The 88-mH surplus loading inductor is also found in a potted form. The potted inductor has two separate 22-mH windings terminated in four insulated wires, which exit the potting compound (see fig. 1). The potting compound is tough and hard. Any attempts to remove the inductor from its potted container will result in damage to the inductor windings. The photo illustrates what happened when I tried to break open the potting compound. Because the inductor windings can't be freed from the potting compound, the inductor must be used in an application requiring either the 88- or 22-mH values. This means that, if the center frequency of a bandpass filter is selected to be a specific value, the bandwidth and termination resistance of the design must be allowed to vary. This is a compromise that must be accepted if the fixed 88-mH inductor is to be used — not particularly objectionable. I will show that these compromises are not unreasonable.

By using modern filter design procedures and the 88-mH potted inductor, high performance CW filters can be designed and constructed where the fixed inductor value is not a disadvantage. The following paragraphs explain the design procedures for obtaining a CW filter for any desired center frequency.

design criteria and procedures

Previously published inductance-capacitance CW filter designs used either one or three resonant circuits (see references 6, 9, and 10). In the two cases

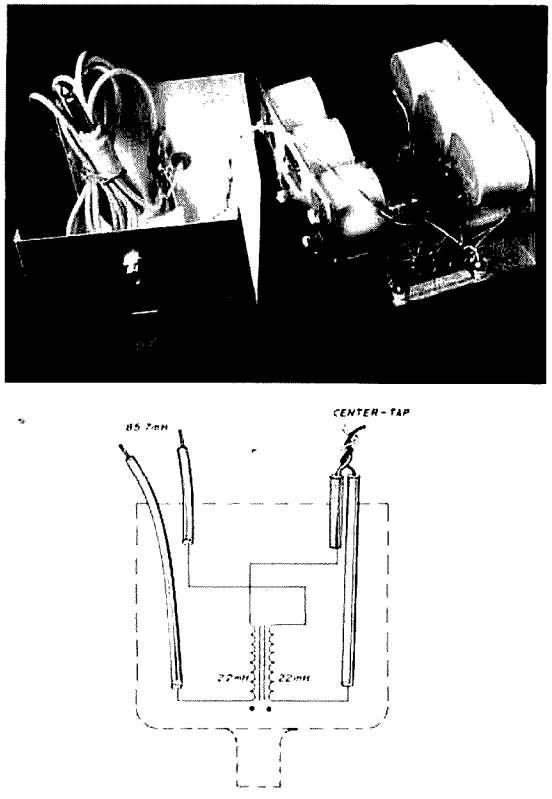


fig. 1. The schematic diagram shows the inductor connections inside the potted case, and the external connection (series-aiding) required for 85.7 mH. The photograph shows the unsatisfactory results of removing the inductor from its potted container. The leads are connected in series aiding for 85.7 mH.

where only one resonant circuit was used, the skirt selectivity was not adequate to warrant serious consideration by the experienced CW operator. The three-resonator filter was better, but it still lacked sufficient selectivity. The design discussed in this article has five resonant circuits, and the resulting selectivity finally provides the performance that the experienced CW operator can appreciate.

Filter center frequency. Because all but one of the filter inductors have a fixed value of 85.7 mH (the reason why the value is not 88 mH was previously explained), it's necessary that the bandwidth (BW) and termination resistance (R_t) be permitted to vary and be dependent on the selected value of the center frequency (f_c). This criterion was used because the designer will want to select a particular f_c, while BW and R_t are of less interest and can be left to fall where they may. Fortunately, for center frequencies between 500 and 800 Hz, BW and R_t values are quite reasonable for the intended filtering application. (Frequencies below 500 Hz are difficult for most CW operators to hear, and for f_c values above 800 Hz, BW becomes a little too broad.)

Filter Q. The widely published filter expert Anatol Zverev states that a very good bandpass filter can be made when its components have a Q not less than twenty times the ratio of f_c/BW_3, where BW_3 is the 3-dB bandwidth. (See reference 16, page 21.) From experience, I've found that satisfactory bandpass filters can be constructed even if the Q is only ten times the f_c/BW_3 ratio. Since the inductor Q used in the construction of this filter varies between 25 and 40 over the frequency range of interest (500-800 Hz), and since the approximate required inductor Q for a satisfactory design is a constant of 30 (the f_c/BW_3 ratio is a constant 3.05 for all designs), I expect that this application of these surplus inductors will be quite practical.

The bandpass filter design is based on a transformation of a five-element (C in/out) Chebyshev lowpass filter having a reflection coefficient (RC) of 6.3 percent. This RC value was chosen because the bandpass filter center inductor is *exactly* one-half the inductance of the end inductors. Thus, if the end inductors are of the 88-mH nominal value, the center inductor can be the standard 44-mH type.

Fig. 2 shows the schematic diagram of the bandpass filter, including the component values for an f_c of 655.4 Hz. In addition to this design, twenty-four other designs have been calculated for f_cs between 496-1087 Hz; they are listed in **table 1. Table 1** data were computer calculated and are based on the **eqs. 1-6** given in **Appendix A**. The tabulated values of C1,5 have been selected to include the standard-catalog capacitor values of 0.25, 0.27, 0.33, 0.47, 0.56, 0.68, 0.82, and 1 μF, with other values slightly above and below the standard values. The other component values and frequency *vs.* attenuation data are included to give an indication of the ranges of values that may be expected.

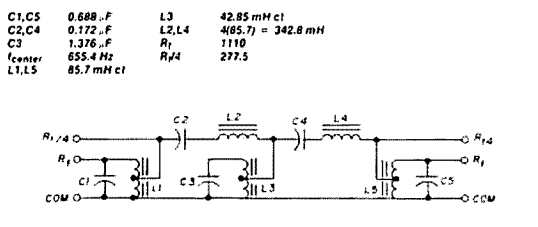


fig. 2. The schematic diagram gives component values of a CW bandpass filter designed for a center frequency of 655.4 Hz. The text explains why L1 and L5 are less than the expected value of 88 mH.

table 1. CW filter parameters for various center frequencies.

F-center (Hz)	C1,5 (μF)	C3 (μF)	C2,4 (μF)	R-term (ohms)	BW-AP (Hz)	BW-3 (Hz)	F-LO(3) (Hz)	F-HI(3) (Hz)	F-LO(30) (Hz)	F-HI(30) (Hz)
1087	.250	.50	.0625	1841	286	357	924	1280	826	1431
1066	.260	.52	.0650	1805	280	350	906	1255	810	1403
1046	.270	.54	.0675	1772	275	343	889	1232	795	1377
1027	.280	.56	.0700	1740	270	337	873	1210	781	1352
961	.320	.64	.0800	1627	253	315	816	1132	730	1265
946	.330	.66	.0825	1602	249	310	804	1114	719	1246
932	.340	.68	.0850	1579	245	306	792	1098	708	1227
802	.460	.92	.1150	1357	211	263	681	944	609	1055
793	.470	.94	.1175	1343	208	260	674	934	603	1044
785	.480	.96	.1200	1329	206	257	666	924	596	1033
733	.550	1.10	.1375	1241	193	240	623	863	557	965
726	.560	1.12	.1400	1230	191	238	617	855	552	956
720	.570	1.14	.1425	1219	189	236	612	848	547	948
664	.670	1.34	.1675	1125	175	218	564	782	505	874
659	.680	1.36	.1700	1116	173	216	560	776	501	868
655	.688	1.38	.1720	1110	172	215	557	772	498	863
604	.810	1.62	.2025	1023	159	198	513	711	459	795
600	.820	1.64	.2050	1017	158	197	510	707	456	790
597	.830	1.66	.2075	1010	157	196	507	703	453	785
549	.980	1.96	.2450	930	144	180	466	647	417	723
544	1.000	2.00	.2500	920	143	178	462	640	413	716
538	1.020	2.04	.2550	911	141	177	457	634	409	708
533	1.040	2.08	.2600	903	140	175	453	628	405	702
518	1.100	2.20	.2750	878	136	170	440	610	394	682
496	1.200	2.40	.3000	840	130	163	422	584	377	653

Design procedure. After selecting a desired value of f_c, use the following procedure to find the filter component values. (See **Appendix A** for design equations.)

1. Find the desired approximate f_c in the first column of **table 1**.

2. Note the required value of C1,5 (**fig. 2**) in the second column, and from a group of about ten capacitors having the proper *nominal* value, select two having a measured capacitance within 1 percent of each other.

It isn't necessary to find the exact tabulated capacitance value, as any slight difference in capacitance between the selected value and that tabulated will only cause a slight shift in the center frequency. The important thing is that C1 and C5 *must* be within 1 percent of each other. (A digital capacitance meter, capable of measuring to an accuracy of 0.1 percent, is recommended.)

3. In a similar manner, select C2 and C4 with a value equal to one quarter of C1 (see **eq. 5B, Appendix A**). If necessary, parallel additional capacitors to obtain the required capacitance within 1 percent.

4. Select one capacitor for C3 with a value equal to twice that of C1 (see eq. **5A, Appendix A**) and within 1 percent of the required value.

5. Connect the parts in accordance with the schematic diagram of **fig. 2**.

6. The shifted value of f_c corresponding to the selected value of C1,5 can be calculated from eq. **1B**.

7. Calculate the R_t value from **eqs. 4C** and **4D**.

8. The bandpass response can be approximated from the values given in **table 1**, or the response can be calculated from the equations given in **Appendix A**.

As an example, the parameters of the filter design in **fig. 2** are listed in **table 1** for $f_c = 655\,Hz$.

CW filter performance

Before starting the construction of this filter, you want some assurance that the selectivity is adequate. This performance characteristic can best be appreciated by referring to a plotted attenuation *versus* frequency response curve. **Fig. 3** shows both measured and calculated relative attenuation responses of the filter in **fig. 2**. I plotted the response on a linear scale to more accurately and clearly define the individual points on the response curve, compared with plot-

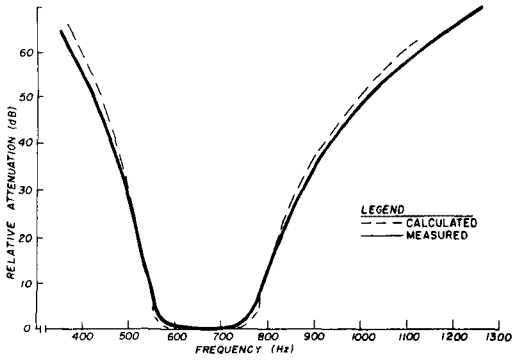


fig. 3. Measured and calculated attenuation responses of the CW filter in fig. 2. The measured response differs slightly from the calculated response because the resistive losses of the filter were not included in the calculations.

ting the response on semi-log paper, where the upper range becomes too compressed for good accuracy. Note the good agreement between calculated and measured values. This agreement indicates that the design procedure is valid, and the inductors are capable of producing a usable filter. The measured insertion loss (not indicated in the plot) is less than 3 dB at the center frequency, which is typical for a filter of this complexity and inductor Q.

Fig. 4 shows the filter response in a semi-log plot,

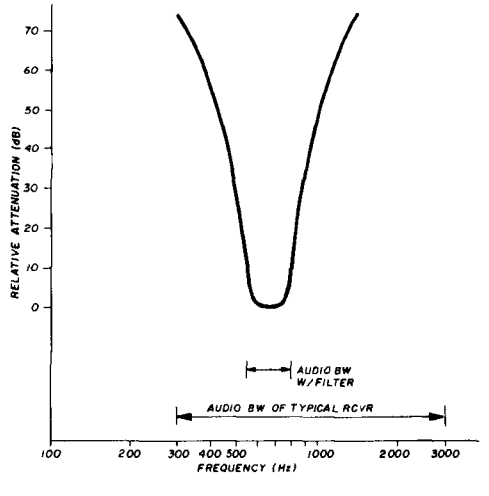


fig. 4. CW filter attenuation response is shown in a semi-log plot relative to the audio bandwidth of a typical Amateur receiver. About 75 percent of the undesired audio bandwidth is attenuated 30 dB or more.

which includes the audio frequency range of a typical communications receiver for comparison. Note that the frequencies below 400 Hz and above 1 kHz are attenuated by more than 50 dB. You should now be convinced that this filter has satisfactory selectivity. Further consideration can now be given to its construction.

construction

The filter was assembled in a $3 \times 4 \times 5$ inch ($7.6 \times 10 \times 12.7$ cm) aluminum box. This box is available from either LMB, No. T-F 779, or BUD, Type CU-3005A, at a nominal cost. There is just enough mounting area on the side of the U-shaped chassis to mount five potted inductors, side-by-side. The other five inductors are mounted on the other side. Holes were punched or drilled in the sides of the chassis, and the shafts of the potted inductor cases were held in place with Tinnerman clips. The 44-mH inductor, terminal strip, and capacitors were mounted on the bottom of the U-shaped chassis.

Fig. 1 shows how the potted inductor leads are connected to obtain the 85.7-mH value. The junction of the soldered leads also provides the centertap connection for L1 and L5. The other two leads were interconnected with the other inductor and capacitor leads in accordance with the schematic diagram of **fig. 2**. After the connections were soldered and taped, the interconnecting inductor leads were positioned along side the potted inductors — no terminal strips are necessary in this case.

The mating portion of the aluminum box contains the audio input cable and terminal strip, audio output phone jack, matching resistors, and the dpdt bypass/through switch. The two filter halves are interconnected with a three-wire cable. With a little care in component placement within the aluminum box, the separate halves of the box will fit together with no interference between the mounted components.

Inductor L3 is most conveniently obtained with a standard 44-mH surplus inductor. The measured value of L3, as received, is actually 42.9 mH; this is the value required for the filter construction. The inductance of the series-aiding connection of the two 11-mH windings is slightly less than the expected 44-mH value because of less-than-perfect magnetic coupling between the two coils. This inductor value is in short supply and is available from only one advertised source.*

It's also possible to modify an unpotted 88-mH inductor, where the number of turns removed depends on the inductor winding configuration. Two winding configurations are currently available — one

*M. Reed, Box 74, Soquel, California 95073. Delivered cost is five inductors for $5.

in which two identically colored windings are wound on separate halves of the toroidal core with two cardboard spacers separating the windings; the other in which the windings are bifilar wound, round-and-round, on the core with two differently colored wires.

The inductor with the two-color bifilar winding has almost perfect coupling between the windings, and this type of 88-mH inductor is recommended for modification to obtain the desired centertapped 42.9-mH value for L3. This inductor is available in a five-inductor stack.†

To modify the bifilar-wound inductor, remove 113 turns from each winding (total turns removed are 226). Connect the start of one color winding to the finish of the other color winding. This junction is the inductor centertap; the other two ends connect across C3 (**fig. 2**).

The 88-mH inductor with two separate windings of identically colored wire is also available from either of the two previously mentioned sources. However, because of its less-than-perfect coupling between windings (about 95 percent), the separate-winding inductor is less preferable than the bifilar-wound inductor for this filtering application. To modify the separate-winding inductor to get the L3 value, remove 110 turns from each winding (total turns removed: 220).

how to get free potted 88-mH inductors

Through the cooperation of the Chesapeake and Potomac Telephone Company of Maryland, I have obtained a large number of potted 88-mH inductors. These inductors were given to me by the telephone company with the understanding that I would distribute the inductors at no cost (except for packing and shipping expenses) to Radio Amateurs for use in their communications activities. The C&P Telephone Company is aware of the public service performed by the Radio Amateur and wishes to foster this important Amateur activity by making these surplus inductors available to those who can use them. The recycling of these high-quality inductors is another example of how responsible industries are attempting to recycle our country's natural resources. (Each surplus inductor, if individually purchased on the commercial market, would cost more than $8.) The CW filter described in this article is a perfect application for these inductors, and those interested in CW communications (CW-QRP net operators, especially) are encouraged to write to me requesting these inductors and to build this filter.

I am serving as liaison between the C&P Telephone Company and Radio Amateurs for distribution of these surplus inductors. First priority for inductor delivery will be given to Amateur-Radio clubs active in some form of community service or civil defense work, and located in the area serviced by the C&P Telephone Company (Maryland, Virginia, West Virginia, and Washington, D.C.). Second priority goes to any club active in some form of community service. To obtain the free inductors, the club president or secretary should write to me requesting a specific number of inductors for a particular application. For example, if four club members wish to construct the CW filter, 40 *potted inductors* should be requested, and the names and call signs of the individuals who will receive the inductors must be included. Those not affiliated with an Amateur Radio club may obtain free inductors by writing and providing details about their application. The priority of their request will be determined from the information they provide.

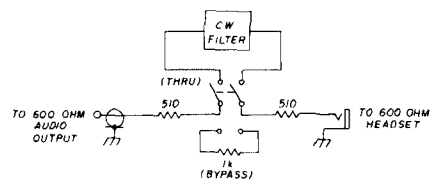


fig. 5. The addition of 510-ohm resistors in series with the filter input and output terminals provides the required filter terminations (1110 ohms) for a 600-ohm audio system. An exact match is not necessary, and any termination within ± 20 percent of the design value will give satisfactory results.

Each request *must be accompanied with a stamped self-addressed envelope*. My response will include packing and shipping costs. If more requests are received than there are inductors on hand, requests will be filled in order of priority until more inductors are received. All requests should be addressed to: Edward E. Wetherhold, W3NQN, 102 Archwood Avenue, Annapolis, Maryland 21401.

installation and operation

For satisfactory filter performance, some attempt must be made to terminate both ends of the filter in a resistive load approximating within 20 percent the design value of R_t or one-quarter of R_t. **Fig. 5** shows a suitable terminating procedure for the filter of **fig. 2** (where R_t = *1110 ohms*) in an audio system having

†TYPETRONICS, Box 8873, Fort Lauderdale, Florida 33310; $3 per stack plus a shipping charge of $1.75 for the first stack and $0.80 for each additional stack. Be sure to specify the preferred inductor type as *scramble-wound red and green wire coils*.

an impedance of 600 ohms. Of course, there will be some signal loss caused by the two 510-ohm series resistors, but the loss is not excessive, and it is easily corrected by simply increasing the receiver audio gain control. A 1k ohm resistor is wired across the THRU/BYPASS switch to prevent an undesired increase in headset level when switching from the THRU to BYPASS position.

Other values of filter R_t may be similarly achieved by the addition of proper series resistance. To do this, however, you must either know or determine the impedance of the receiver audio output and of the headset. In some instances, it may be necessary to add resistance in parallel with the filter input and output to obtain the desired filter termination resistance.

Vacuum-tube receivers usually have an audio output impedance of 600 ohms, while the modern transistorized communications receivers may have an output impedance of between 4 and 8 ohms. When the receiver output impedance is very low, the addition of series resistance may not be feasible, because the audio output stage may not be able to provide sufficient output to overcome the excessive signal loss caused by the high value of series resistance. In this case, a matching transformer, such as the Radio Shack 273-1380 or equivalent, 8/1000 ohms center-tapped, should be connected with appropriate series resistors to provide a suitable match. A small 115/6.3-volt filament transformer may also be used, since it has a suitable turns ratio for transforming a 4-ohm source to around 1300 ohms, which is within the recommended ± 20 percent range of termination resistance (1000-1600 ohms) for f_c values from about 600-950 Hz.

In addition to my experiences, several other Radio Amateurs have constructed this five-resonator filter design in which either the ten potted inductors described in this article or two five-inductor stacks were used.[20] In either case, the users were satisfied with the filter performance, and in many instances the filter made it possible to continue contacts which otherwise would have been lost. The filter bandwidth is wide enough to slightly shift the CW beat note within the filter passband, but the bandwidth is narrow enough to provide the required selectivity for effective communications.

summary

The advantages of filter design using network synthesis were briefly discussed, and a design example was given for a passive five-resonator bandpass filter suitable for CW application. To minimize cost, surplus inductors were used, and procedures for obtaining ten of the 88-mH potted inductors at no cost (except for packing and shipping expenses) were explained. Performance of the completed filter was thoroughly documented with two attenuation response plots, and a table of filter component values and response parameters was included for center frequencies between 496-1087 Hz. A photograph showed how the filter components could be assembled in a standard $3 \times 4 \times 5$-inch ($7.6 \times 10 \times 12.7$ cm) aluminum box. A detailed appendix of design equations provided information so the interested reader could apply the design principles to other filtering requirements. Background material and sources of additional information were provided in a reference listing of twenty books and articles.

acknowledgments

I gratefully acknowledge the assistance of Frank Noble, W3MT, for constructing a filter in accordance with the instructions provided in this article, and for providing comments and improvements based on his construction and operating experiences. I also gratefully acknowledge the efforts of Joseph Gutowski of EWC, Inc., and Rex Cox of Honeywell, Inc., for their review of the article.

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appendix A

design equations for the bandpass filter of *fig. 2*

$$f_c = 1/[2\pi\sqrt{L1\,C1}] \quad (1A)$$

where f_c = center (geometric mean) frequency (Hz)
$L1$ = inductance (Henries)
$C1$ = capacitance (Farads)

$$f_c = 543.66/\sqrt{C1} \quad (1B)$$

where $C1$ = capacitance (μF)
$L1$ = 85.7 mH

$$C1 = 295,569.4/f_c^2 \quad (1C)$$

where $C1$ = capacitance (μF)
$L1$ = 85.7 mH
f_c = center frequency (Hz)

$$f_c = \sqrt{f_{LO_x} f_{HI_x}} \quad (1D)$$

where all frequencies are in Hz, and f_{LO_x} and f_{HI_x} are the lower and higher frequencies at the "x" attenuation level on the filter attenuation response curve (see **fig. A-1**).

$$BW_{A_p} = f_c\sqrt{(G1\,G2)\,(L1/L2)} \quad (2A)$$

where $G1$ and $G2$ are the lowpass filter element values normalized for an f_{co} of one rad/sec and one-ohm terminations.
$L1$ and $L2$ are in Henries
A_p is the peak level (dB) of the passband attenuation ripple.
BW_{A_p} is the bandwidth (Hz) at the A_p attenuation level (see **fig. A-1**)

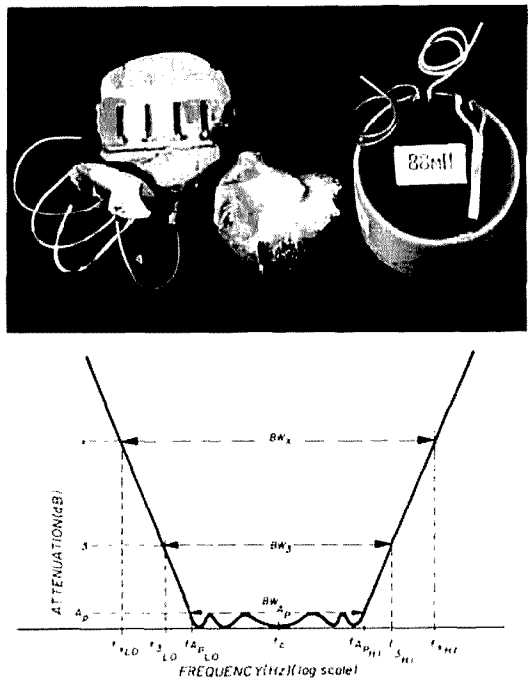


fig. A-1. A typical attenuation versus frequency response of a bandpass filter includes the parameters defined in *Appendix A*.

$$BW_{A_p} = 0.25 f_c\sqrt{G1\,G2} \quad (2B)$$

where $L1/L2 = 0.0857/[(4)(4)(0.0857)] = 0.0625$

$$BW_{A_p} = 0.26285 f_c \quad (2C)$$

where $G1 = 0.8265$ and $G2 = 1.3375$ for a 5-resonator Chebyshev bandpass filter with reflection coefficient $(RC) = 6.3$ *percent*

$$BW_3 = 1.248\,BW_{A_p} \quad (3A)$$

where BW_3 = 3-dB bandwidth of a BP filter for a 5-resonator Chebyshev BP filter with $RC = 6.3$ *percent*

$$BW_3 = 0.328 f_c \quad (3B)$$

$$R_t = 2\pi\,(BW_{A_p})\,(L2\ G2) \quad (4A)$$

where R_t = termination resistance (ohms). See **equations 2A, B, C** for values of $L2$ and $G2$.

$$R_t = 6.4415\,BW_{A_p} \quad (4B)$$

for $L2/G2 = 16\,(0.0857)/1.3375 = 1.3712/1.3375 = 1.0252$

$$R_t = 920.5\sqrt{C1} \quad (4C)$$

where $C1$ = capacitance (μF)
R_t = resistance (ohms)

$$R_t = 1.69314 f_c \quad (4D)$$

where f_c and R_t are in Hz and ohms for $L1 = 85.7$ mH

$$C3 = 2(C1),\ L3 = (L1)/2 \quad (5A)$$

where C and L are in μF and mH

$$C2 = (C1)/4,\quad L2 = 4(L1) \quad (5B)$$

See **fig. 2** for location of all Cs and Ls

$$BW_x = \Omega_x\,(BW_{A_p}) \quad (6A)$$

where BW_x and BW_{A_p} are the filter bandwidths at the "x" and A_p attenuation levels, and Ω_x is the normalized bandwidth at the "x" attenuation level relative to the bandwidth at the A_p attenuation level; that is, $\Omega_x = (BW_x)/(BW_{A_p})$

$$f_{LO_x} = -b_x + \sqrt{f_c^2 + b_x^2} \quad (6B)$$

where $b_x = (BW_x)/2$

$$f_{HI_x} = f_{LO_x} + BW_x \quad (6C)$$

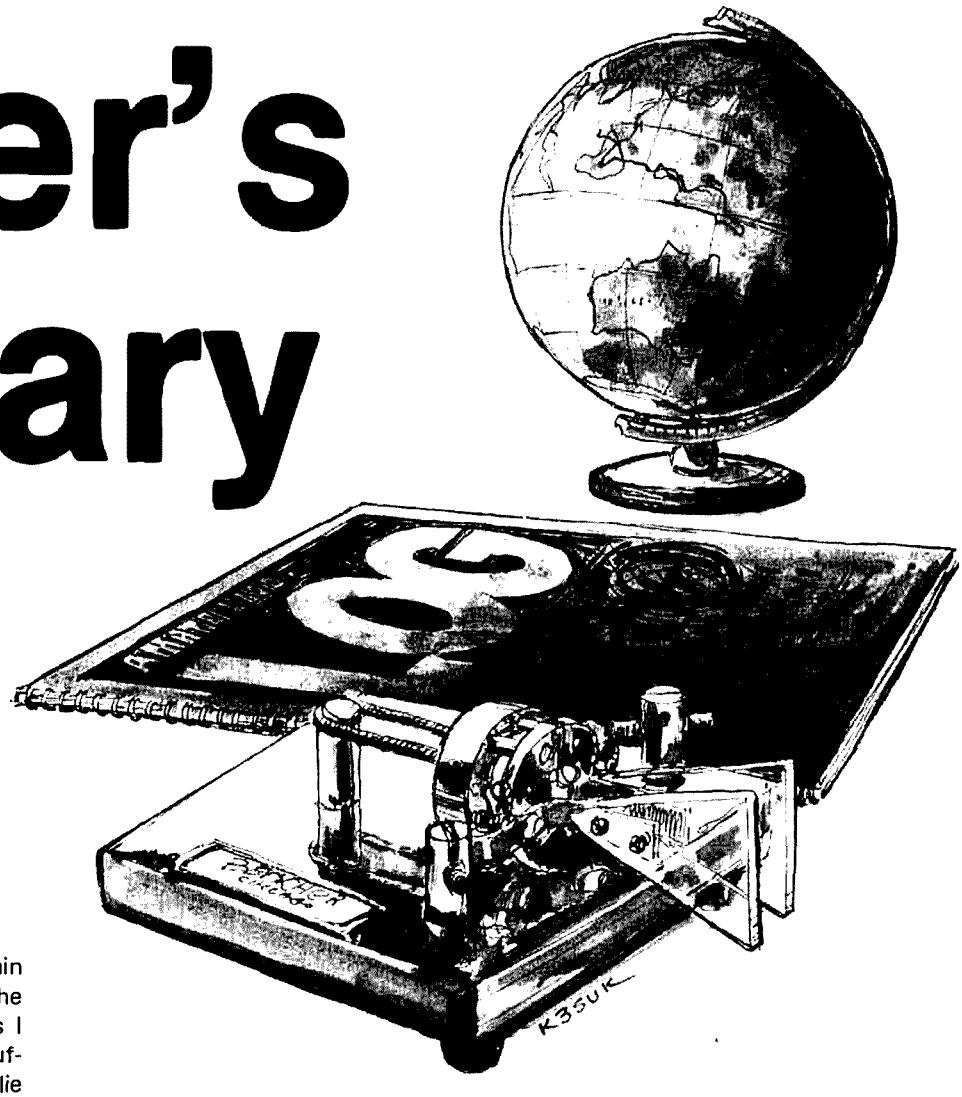
See **eq. 1D** for the definitions of f_{LO_x} and f_{HI_x}.

The attenuation levels for eleven values of Ω_x are listed in **table A-1** for a five-resonator Chebyshev filter with $RC = 6.3$ *percent*. To find BW_x corresponding to a particular Ω_x and for any given f_c, calculate BW_{A_p} (using **eq. 2C**), then calculate BW_x (using **eq. 6A**).

table A-1. Attenuation (dB) as a function of Ω_x.

Ω_x	attenuation
1.00000	0.0173
1.24800	3.0000
1.33800	6.0000
1.40000	8.3000
1.60000	15.6000
2.00000	27.2000
2.11665	30.0000
2.50000	38.0000
3.00000	46.5000
4.00000	59.6000
4.50000	64.9000

DXer's diary



By Bob Locher
W9KNI

Getting up at 5 AM is a pain: a pain everywhere in my body. I turn off the insistent alarm clock as quickly as I can to avoid disturbing my long-suffering wife more than necessary. I lie back again to rest my complaining muscles, sore from yesterday's gardening. She says:

"Hey! If you're going to the trouble to set the clock for 5 AM, you'd better get up!" I snap back from dreamland — she's right. Poor thing — she's wide awake now, while I'm barely alive. *She* should be the DXer!

I groan and swing my feet out of bed.

"Thanks, kid. I'm up now."

"Think nothing of it, my man." We laugh, and I start fumbling for my bath robe and slippers.

I flip on the switches on the gear and head back to the kitchen for my wake-up cup of coffee. In minutes I'm slumped in front of the receiver, only half awake, shivering a little. But I sip the coffee, and its warmth helps me slowly focus my thoughts.

I start tuning 20. The band is very quiet; only a few signals, and these mostly buried in the mud. Hey, there's one a little stronger — let's copy him and see where he is. OK, it's VK4RF. Boy, he's not very strong. Bob, you turkey, why don't you try turning the antenna to the west instead of north? Sometimes I'm so dumb even *I* notice it. I haul the antenna around, but the VK4 is gone now. So I tune on.

The band sounds a lot better now; many more signals. I find several loud VKs. There's a ZL, nice signals, too. OK, there's ZK1CT; a nice catch, but I already have him. I hear a weak signal — I switch in the audio filter and tune him in better — oh! OK, it's YU3DX, probably trying to help open the long path.

I look over my blackboard where I keep notes on the various DX stations I'm chasing. There it is, taking up a quarter of the board:

According to responses from our readers, Bob Locher's adventures in the DX world are extremely popular. Here's yet another episode in Bob's trials and tribulations. Looks like brother Murphy and his laws were operative this time. But no fear! Perserverance and dedication will really pay off. Try and try again! **Editor.**

VK9NV 14042 at 1117Z 4/19
14047 at 1140Z 4/22
14064 at 1157Z 4/25
(reports all gleaned from my DX bulletins.)

The pattern is pretty clear. The VK9 likes 1100 Zulu, so here I am plighting my troth, as it were.

This VK9 has been a real hard-luck story for me, with hours and hours of lost sleep piled up, and absolutely nothing to show for it. No wonder DXers grow gray hair.

If I get up at 5 AM on Tuesday, Wednesday, and Thursday, next week's bulletin is full of reports on his operations Monday and Friday. If I get up every night for a week, that's the week he's on vacation, or his antenna falls down. My buddies all catch him one night — the week *I* was on vacation! If I get up every night at 1100Z the week after *he returns from* vacation, he starts operating at 0900Z instead of 1100Z. If I discover that he has a sked with his QSL manager, a VK6, at 1000Z, sure enough — we get a disturbance and the band is dead.

But hope, the lifeblood of a DXer, springs eternal. Maybe today's my chance, in this forsaken hour of the dawn.

I move the receiver dial to 14040 and begin an intensive tune up the band. As I cross each signal, I try to identify it as to its possible location. The only strong signals I'm hearing are VKs and South Pacific stations. The weaker signals are faint Europeans, back-scatter Americans and Canadians, and the occasional crooked-path JA.

I have some other clues of my prey besides hints of his operating habits. His name is Nigel. He has a very clean, pretty fist, but doesn't appear to be any speed demon. *His signal is* clean, and of average strength for the VKs and ZLs. I obtained all this information from my pals who worked him and from the bulletins.

His QTH, Norfolk Island, lies off the eastern coast of Australia and is an easy propagation shot, which compounds the difficulties. It means that there are more hours of the day that the path is open; more hours to watch. And all at the wrong times. Like at 1100 Zulu.

Finally, I'm really beginning to wake up. I keep tuning. Signals seem to be building slowly as sunrise approaches. There's VK5FM calling CQ. There's a weak signal — yes — it's JAØCUV/1. There's a louder one — "NAME HR TREVOR," and another, "QTH SYDNEY? SYDNEY."

I hear "579 HR IN PORT MORESBY," "CQ CQ DE VK6RU," "73 SK N6RJ DE H44PT." The band really is in pretty nice shape. I look at the dial calibration — 14082. I spin the receiver back down the band. Guess I'll try starting at 14030 this time. I start my climb back up the band.

A thought hits me. I pick up my 2-meter microphone. "Hey, anybody alive out there? Here's W9KNI."

"Yeah, good morning Bob. W9KNI here's K9BG. What are you doing up at this hour?"

"Hey, good morning Jerry. Yeah, I guess it's morning. I'm looking for VK9NV, again. I'm tuning 20 CW for him. What are you doing up?"

"I thought I'd have an early look around 80 CW. I still need that zone 29 on 80, and VK6RU has been down there, so I'm told. But all I hear on 80 is loud QRN, and KH6XX, and he's not very strong. So I'm working over 40 CW now."

"Yeah, OK Jerry. Well, don't waste your time on VK6RU; I heard him here on 20 a couple of minutes ago calling CQ. Guess 80 must be no bargain at his end either this morning."

"OK, Bob, thanks. But 40 isn't too bad; I'm hearing lots of ZLs and VKs, *and some good JA signals, too. If I* hear that VK9, I'll call you for sure. W9KNI from K9BG."

"Fine, Jerry and thanks. If I hear anything good on 20, I'll call it in. K9BG from W9KNI."

My coffee cup is empty, so I run upstairs for a refill and am back at the rig in a few moments. Signals seem to continue to build up. I glance out the basement window, to see the first glimmer of the approaching dawn. I begin to tune up the band again. There sure are a lot of VKs on. But wait! It's Friday morning here and they are on the other side of the date line, so it's Friday evening there and they're starting their weekend. Sure wish I was. No wonder there are so many of them out.

I continue to try to identify signals. The clues I have are a big help; when I hear "OP HR TREVOR" I know it isn't my boy Nigel. "QTH HR DARWIN" means QTH here *isn't* Norfolk Island. I listen to all CQs but usually have to wait only a few seconds before the station calling signs his call.

With more and more signals coming up, it's slow going. I glance at the clock. It's 5:35, 1135 Zulu. If my intelligence information is correct, he certainly should be on by now. I keep tuning, inspecting every signal closely. Some I can dispose of in a moment; others take several minutes before I obtain an adequate identification. And there's one QSO going at 14055 where the two stations are breaking back and forth without exchanging call signs.

Unfortunately, one of the two stations in the QSO perfectly meets the profile I'm using, to the extent that I can observe and glean information *from what I hear*. Nice, *clean* steady fist, average signal strength, and having a good old-fashioned ragchew with his buddy. "WX HR DRY TODAY." That's no help. Being dry is relative, it could be a dry day anywhere. If the mystery station had said it was snowing, I could tune on with confidence, because snow on Norfolk Island is highly unlikely!

I continue to listen for a few minutes, but no call signs. I can't afford to stay here too long — if one of the stations isn't the VK9 — and the odds are certainly against it — the

VK9 might be 5 kHz away and I'd never know it.

I decide to make note of the frequency and set my transmitter VFO on it and move on. That way I can keep jumping back to check out that QSO in hopes of finally catching a call sign.

My 2-meter radio squawks, "H44PT, H44PT Seven Oh Two Nine, Seven Oh Two Nine, that's H44PT, Seven Oh Two Nine, from K9BG." Hmmm. So that H44 on Guadalcanal moved to 40. OK. I was thinking of taking a look at 40, but with Jerry there watching, I'll concentrate on 20.

I zip back to the mystery QSO. Phooey — they're still going strong, and no ID. The worst of it is that a rare station who wanted a ragchew with his pal would do it exactly *that way* to avoid attention; but that's no guarantee that *these* fellows are rare.

I tune further up the band again. Lots of signals, but no goodies. I jump back to the mystery QSO.

"OK GEOFF TNX FOR KEEPING SKED QSP 88 TO HELEN ES 73 UR KIND SELF CU NEXT WEEK." Hah! One of them's signing clear. I check my VFO to see that I'm zero beat. I'm ready. "CHEERS VK6RZ DE VK7OT SK."

Rats! Nothing there for me.

The basement lights blink: a signal from my wife that she wants to talk to me. I lift up the headphones.

"Bob, I've made a cheese omelet and some sausage. Would you like some breakfast?"

Any remaining resolve to rough it out on the line of scrimmage instantly evaporates.

"Great. I'd love some. I'll be there in a second."

"OK, I'll pour you some fresh coffee."

I pick up the 2-meter microphone. "Jerry, I'm going to get some breakfast. Call me if you find anything. I'm leaving the volume turned up. K9BG from W9KNI."

"OK, Bob. Go ahead. I'll be here a while. W9KNI from K9BG."

An omelet, sausage, and hot coffee; a real treat compared to my usual roll eaten at my desk.

"No luck, huh?" my wife asks, as she sets my plate in front of me.

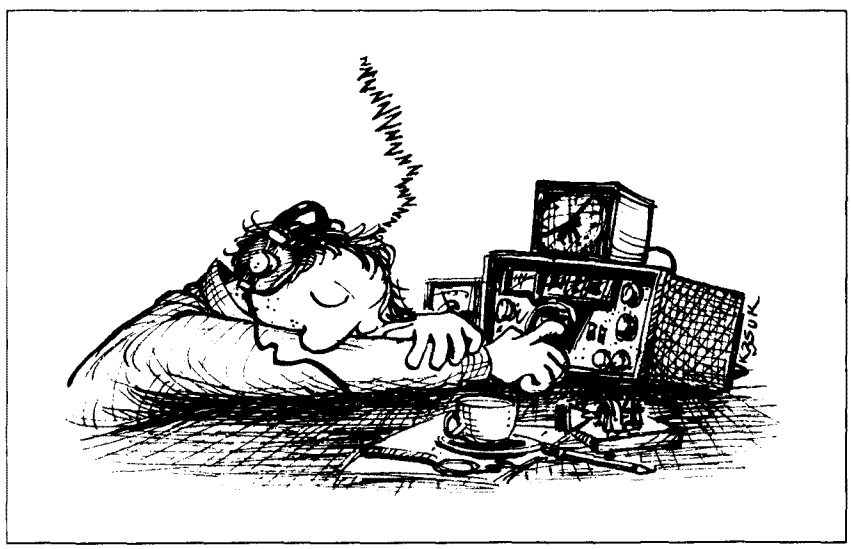
"No, I think I'm snakebit on that one. How come you're up so early?"

"Once the clock went off I couldn't go back to sleep, so I thought I'd fix us a nice breakfast since we're both up."

I'm *nearly* finished with my breakfast when my 2-meter radio howls from the basement, "Hey, Bob! W9KNI, there he is! Hurry. W9KNI from K9BG. He's on 7019 calling CQ!"

I have the receiver on him now. Yes, there he is. "KØMM KØMM DE VK9NV GM OM..."

"OK, Jerry, I hear him. Thanks a lot." I move my VFO a couple of kHz above him and start tuning. The linear plate current, grid current, and rf output start climbing as I advance the exciter drive control. Then, it happens: suddenly, no output! Hey — almost at the same instant, the acrid, smoky smell of a hot component burning assails my nose. Startled, I look at the exciter, just in time to see a column of smoke dissipating over the final-amplifier compartment of the exciter. Oh, no!



In a very few seconds I'm in front of the rig, swallowing the rest of my sausage. I grab the 2-meter microphone. "OK, Jerry, thanks. I'm getting tuned up. If no one comes back to him, why don't you work him to hold him on the frequency? K9BG from W9KNI."

"OK, he's signing now."

I yank the receiver bandswitch down to 40 and spin the dial to 7019. With the other hand I switch the bandswitches on the exciter and the linear. Then I turn the antenna switch and preset the dials for a fast tune up.

"OK, Bob. He's got two or three people calling him. Hear him OK?"

"He's signing clear, Bob. Are you ready?"

"Ugh. Jerry, my rig just blew up. I smell smoke from something, I don't know what. I'm going to try to fix it as fast as I can. K9BG here's W9KNI."

"Gosh, Bob. Sorry to hear that. You *are* snakebit with that guy. I'll let you have at it. W9KNI from K9BG clear."

"Thanks, Jerry."

It's panic time. If I'm quick, maybe I can fix the rig while he's still on. Plug in the soldering iron. Grab the Phillips screwdriver, the side cutters, the needle nose pliers and the solder

from the tool kit. Grab the VOM. Unplug the exciter. Pull off the coax cable and the control cables. *Jeez!*

Lift the top lid. Out come the two screws there. Put them on top of the receiver so they won't get lost.

Up on its back. Off come the feet. OK, *turn it over* again. There, OK. Gingerly, now, slide it out of its case. There, OK. Now up on its side.

I don't have to look far to see the source of the smoke. Underneath the final compartment I find a charred, blackened corpse of a 2-watt resistor. Must be a part of the screen circuit. There's no hope of reading the value. The color-coding stripes are only blackened faint scars on the blistered body.

I put the VOM across the part. Hmmm. I get a reading approaching one megohm, probably from other circuit elements. I yank the manual for the rig out of the file drawer and open it to the circuit. Then I begin draping the schematic foldout across the table. I find the section showing the final and fold the drawing mostly back up, so that I don't cover all my tools. Time, precious time!

Yes, there is a 2 watter. Let's be sure it's the one. Yes, it appears to be the only one in the final cage. And yes, it goes from that pin terminal 3 with the jumper to the other tube, and to the tie point where that point oh-one disc cap is. Yes, that's *got* to be the part. OK, it's an 18k resistor.

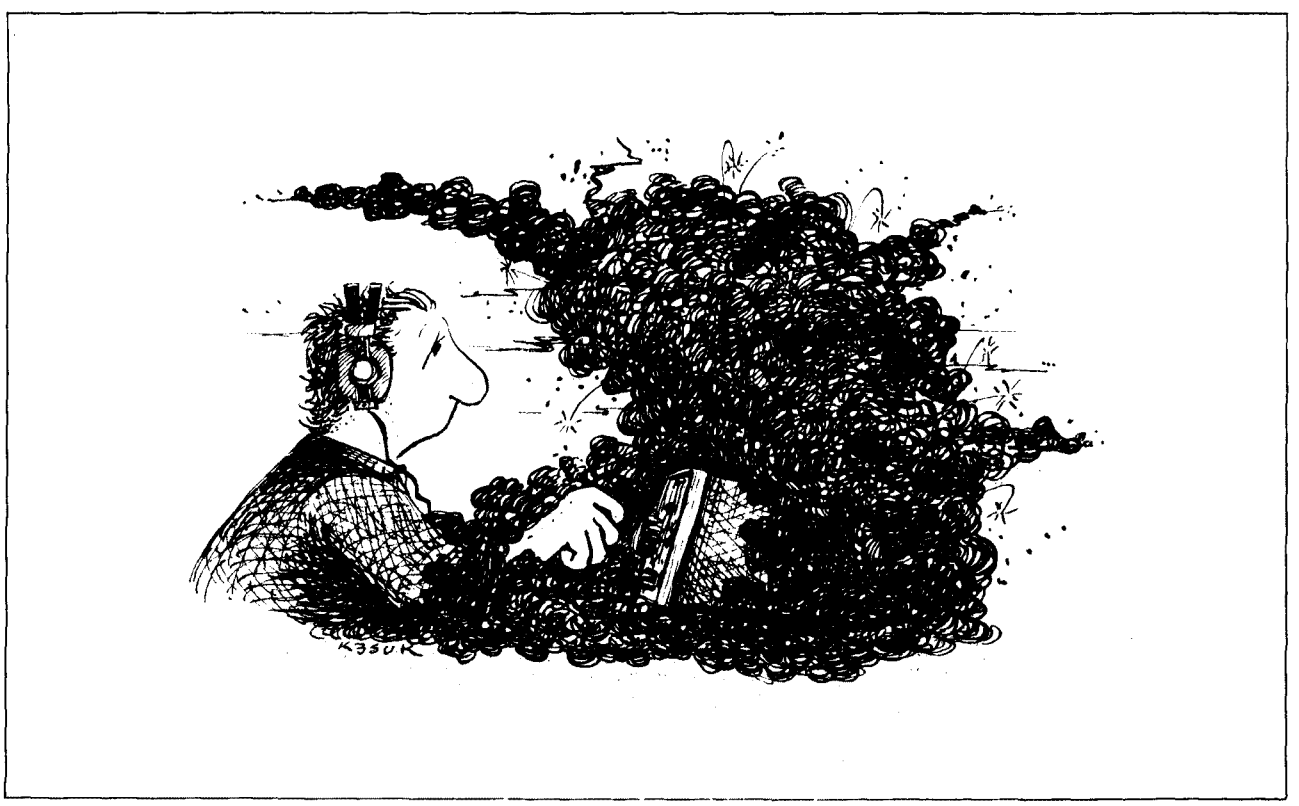
I jump over to the work bench and pull down the coffee can marked *resistors*. Lessee here. "Bad boys..." OK. Brown, Gray, Orange. Sure hope that I have one. That isn't the most common value.

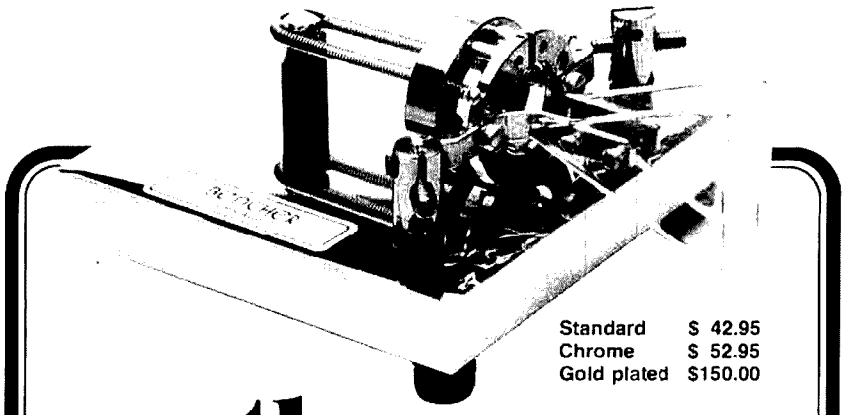
I dump the contents of the can across the table. Hey, there's one! Maybe my luck is turning after all. I grab it and almost instantly I'm back at the rig. I look at the leads of the burnt resistor. While the ends of its leads are not particularly inaccessible, I decide to use the existing leads of the old resistor to carry the new component, in the interest of speed.

Snip, snip, with the side cutters, and the old resistor is out. A few moments work with the needle nose pliers, and the new resistor is supported by the leads of the old one. A touch with the soldering iron on each end, and the part is in. I cut the ends off it, then slap the ohmmeter across the circuit. OK, it's showing 17k ohms. Close enough. I unplug the soldering iron, and slide the tools out of the way.

I know I'm cheating a bit. I'm making the supposition that my rig problem is *only* and *completely* the failed resistor. If there's another problem that caused the resistor failure, I've done nothing to find it.

I know I'm gambling — but if I'm to have any chance to snag that VK9, the rig has got to work *now*. The time necessary to check out the adjacent circuitry would surely cost me any chance of a shot at the VK9.





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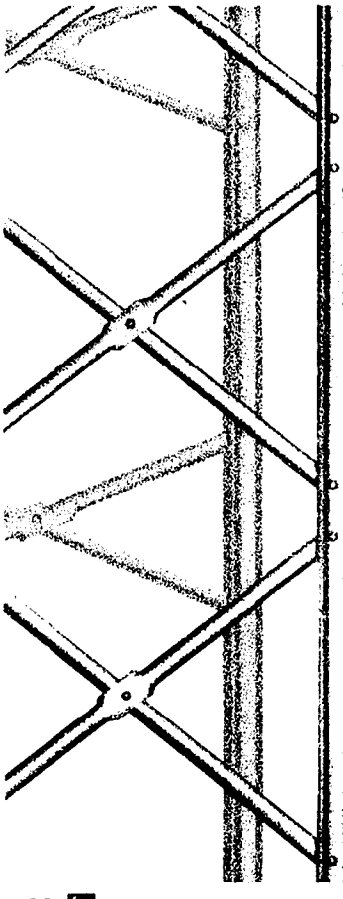
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OK. I set the rig on its bottom and frantically start plugging in the various cables — coax, keyer, AC, PTT line, linear control. Forget the cabinet; I'll just be careful to keep my fingers out of it and put it back in later. Nobody watches TV at this hour of the morning anyhow.

With all the cables plugged in, I switch on the rig. So far, so good; the VFO dial face lights up, as does the meter pilot lamp.

"Hey, W9KNI from K9BG. Bob, are you having any luck?"

"OK, Jerry. I just replaced a smoked resistor and the rig is warming up. I haven't tested it yet. Is he still there?"

"Yes, he is, but he's a little bit weaker. I think he's workable, though."

"OK, if the rig works I should be ready now. Cross your fingers! K9BG from W9KNI."

I close the push-to-transmit switch. The relays pull in. Uh oh! No plate idling current showing on the exciter meter. That's a bad sign. I start to apply a little drive. Just then I hear a faint click, and a puff of smoke rises from the back of the rig.

Rats. *Aaaagh. Ah, Phoooey.* Darn. Son of a gun. Heck. Aw, shucks. Ouch! (Actually, that's not what I said, but, you know...)

Well, I gambled and lost. I would do it again the same way under the same circumstances.

"Hey Bob, he just went QRT. He said he'd be back tomorrow though. Did you get your rig working?"

"No, Jerry, but thanks. It figures. I really am snakebit on that guy. Well, I hope I can fix the rig by then. Hey, it's after seven. I have to get dressed and get out of here. I'm late. See you tomorrow, Jerry. Thanks for your help. K9BG here's W9KNI, clear. Good morning."

"OK, Bob. Hope you get it going OK tonight. 73, have a good day. W9KNI from K9BG, clear."

I turn off everything, and head up the stairs. It's going to be a long day — but it can only get better from here. And there's always tomorrow.

ham radio

transient protection
for the Collins 516F-2 power supply

Solid-state devices provide improved efficiency and reliability

Power supply failures that seem unexplainable have been experienced by most of us at one time or another. In our haste to get back on the air, we probably resolved the problem by inserting a new tube, a capacitor of higher voltage rating, or a larger fuse. It is the intention of this article to emphasize an ever-present danger of catastrophic failure from voltage transients, and to recommend power supply modifications that reduce that danger.

I've heard that if the cost of transient protection is considered to be high, then so is the cost of a good safety belt. It is true that the replacement costs for new transformers, rectifiers, and meters may be relatively *high* by *comparison*.

The Collins 516F-2 power supply was selected as the subject of this article primarily because more than 30,000 of these units are believed to be scattered around the Amateur community. In this article, application of transient protection and substitution of silicon rectifier assemblies for hard vacuum tubes is explained, using the 516F-2 as an example. The information is general enough, however, that it can be applied to most power-supply modifications.

At a minimum, modification should include the addition of primary transient protection. The poor 5R4, as used in the 516F-2, was rarely if ever run within its ratings; this should be reason enough for substituting silicon rectifiers for hard vacuum tubes when

An interesting coincidence came to our attention regarding the low-voltage potential of the Collins 516F-2 power supply. Paul Pagel, N1FB, made modifications to his supply using virtually the same method as described by W6AD. However, while working beneath the power-supply chassis, N1FB added a 100-volt, 1-watt zener (HEP Z0438) between R8 and R9 junction and ground. This device held the bias voltage to within a volt or so of its set value, whereas before this addition the bias voltage wandered considerably with the changing transformer load during CW keying. Editor.

By Ozzie Jaeger, W6AD, P.O. Box 685, 803 Seacliff Drive, Aptos, California 95003

modifying any power supply for transient protection.

Like antennas, transient protection is a subject often discussed but not always well understood. This article is not intended to rectify that situation; instead, it provides the important, basic facts in a simple manner, so that modifications can be made without need of complex charts or mathematical formulas.

This article answers the following important questions:

1. What changes are needed to the supply?
2. Where do I get the materials, and how much will they cost?

need for transient protection

Suppression devices (or clippers, if you prefer) are used to protect against possible damaging effects of power line or internally generated transient voltages. These transients have been known to cause complete destruction of semiconductor as well as tube devices. Damage occurs when transient voltages exceed the maximum limits of power supply components. The sources of these transients are well known and are not discussed in detail here. They generally occur as a result of the familiar basic relationship:

$$e_L = -L\,di/dt \qquad (1)$$

where e_L = voltage across inductor (volts)
L = inductance (henries)
i = current (amperes)
t = time (seconds)

This equation can be interpreted to mean that anything causing rapid switching of a high current is liable to generate a troublesome transient. Typical examples are:

1. Energizing or de-energizing a transformer primary (turning the supply on or off)
2. Connecting or disconnecting secondary loads
3. Semiconductor switching, such as by an SCR, or reverse recovery transients in the rectifiers themselves
4. External disturbances from motors, solenoids, or relays that share the same power line

Transients of widely varying magnitudes are found in all electrical systems; some of them can be highly damaging.

circuit applications

There are several methods of transient suppression; some are more effective than others, depending on circuit complexity. Only the one which lends itself best to Amateur applications (that is, low cost, ease of installation, and parts availability) is considered appropriate for modification of the 516F-2 power supply. Before that choice is identified, the various techniques are briefly discussed.

Transient protection methods are classified as follows:

1. RC networks
2. Silicon voltage limiters
3. Metal oxide varistors
4. Selenium suppressors

RC networks. These are relatively inexpensive and provide excellent performance when used in conjunction with other means of transient protection. RC components are often quite large, especially when connected across the secondary of the power-supply transformer. Nevertheless, they are used widely in applications from small power supplies for transistors or integrated circuits to hard contact starter/contactor applications. For design purposes, the maximum energy expected to be present during a transient should be known. Energy is expressed as:

$$E_{max} = 1/2\,Li^2 \text{ or } 1/2\,CV^2 \qquad (2)$$

where $E_{max} = 1/2\,Li^2$ or $1/2\,CV^2$
V = voltage (volts)
C = capacitance (farads)

A typical RC circuit is illustrated in **fig. 1**. A small ac current flows through this circuit under steady-state operating conditions. In the event of a transient, large currents flow for brief periods. The resistor reduces the secondary circuit Q and absorbs some of the transient energy. I feel that the complex details needed to provide design information for the RC circuit is probably not of interest to most Amateurs. However, those wishing further details should send a self-addressed, stamped envelope to the author.

Other types of suppressors are often used in combination with RC networks to provide better suppression. When used with the MOV (metal oxide varistor) or break-over diodes, the RC network provides a higher level of energy absorption. The tradeoff here is one of economy, since the combination allows

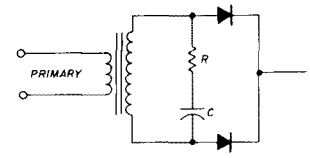


fig. 1. Circuit of a typical RC transient suppressor.

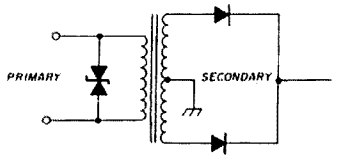


fig. 2. Circuit diagram showing a transient suppressor connected across transformer primary.

lower-voltage power supply components to be used.

Special silicon voltage limiters. These devices consist of back-to-back avalanche diodes (zeners) constructed on a single substrate. In the circuit, one diode is always in the conducting mode, while the other is in the blocking mode, as illustrated in **fig. 2.** Much more can be said about this device and its excellent protection characteristics, but despite its good points, it is much too expensive for typical Amateur equipment. The silicon limiter is temperature sensitive; special care should be taken to ensure adequate heat sinking to keep its case temperature below about 260 F (125 C).

Metal oxide varistors. These are zinc oxide/bismuth oxide ceramic devices. When used for transient protection, varistors act as clippers of incoming transients or transients caused by switching transistors. The power dissipation capability and current and voltage ratings are temperature dependent, so it's important to know the ambient conditions under which they will be operated. The manufacturers derating curves are generally available and should be consulted to establish temperature compatibility.

Metal oxide varistors also have a high capacitance characteristic, which limits their use to relatively low frequencies; however, since most Amateur applications use power-line frequencies, this should present no problem.

Selenium transient suppressors. Probably the type best suited for Amateur applications, selenium suppressors provide transient protection because of their sharp reverse voltage breakdown characteristics. They are available in either dc (polarized) or ac (nonpolarized) types, and each has an rms and dc rating of 24 volts per cell. When the unit is connected across the transformer primary (where most of the units will be used), it will draw a small, constant amount of current. However, in the event of overvoltage, a much larger amount of current will be drawn through the device for a very short period of time; this will limit the maximum voltage applied to the transformer primary, thereby possibly preventing a catastrophic failure of a rectifier or filter component on the secondary side.

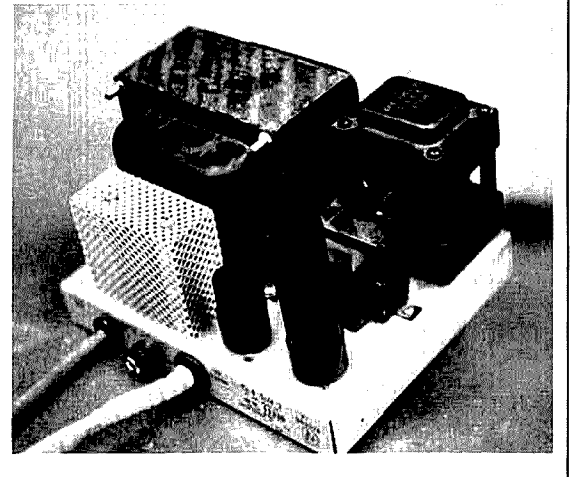
Selenium suppressors are available either in the axial lead or series metal plate type. Ninety percent of existing Amateur equipment includes power supplies in the 25-400 watt range. The small axial lead suppressors are entirely satisfactory for these units. If space permits, or in case you're interested in protecting a really large power supply, the 1-inch, 1½-inch, or even the 2-inch selenium units should be used. It may be comforting to know that the large Voice of America broadcast station transmitters, with ac primaries up to 480 volts, use selenium suppressors exactly like those shown in the photographs. In addition, many large steel mills and foundries, and broadcast and TV stations use selenium suppressors of this type in their high-voltage power supplies. The fact that selenium suppressors are used in mountain-top and other difficult-to-reach telephone installations is testimony to their effectiveness.

Selenium units operate effectively in ambient temperatures up to 120 F (49 C). This characteristic should not be a problem for Amateur equipment. Finally, selenium suppressors have an energy-absorbing ability that is measurably better than that of any of the other devices discussed.

modifying the 516F-2

The importance of adding transient protection to power supplies has now been established, and the selenium type has been selected as the best choice for Amateur use; therefore, modification of the 516F-2 can now be described. Proceed as follows:

1. Remove blue wire from pin 2 on V2 (5U4 socket)



The Collins 516F-2 power supply after modification. The silicon replacement rectifiers substitute for the rectifier tubes.

2. Mount a new 25-watt, heat-sink-type resistor on back chassis apron between V1 and V2 sockets (100 to 200 ohms)

3. Connect blue wire taken from pin 2 of V2 to the end of the new resistor being added

4. Connect other end of resistor to pin 2 of V2

5. Wire axial lead transient suppressor across transformer primary. Make the connections to one side of the fuse (ring section, not tip) and to the triple tie-point that already contains two black wires

6. Plug in the 5U4 and 5R4 silicon rectifier replacement units

After completing the modification (**fig. 3**) you'll find that the low voltage will be approximately the same as originally, but there will be 40 to 60 additional volts on the 6146 plates. To bring the static current back to its original value, readjust the bias pot.

While there is no danger in applying an additional 50 volts or so to the 6146s, the higher voltage that would be obtained in the low-voltage circuits could be disastrous. This explains why the 25-watt resistor is added in step two of the modification instructions. If you succumb to the temptation to leave this resistor out, you may achieve slightly higher power output, but you also guarantee shorter tube life. Considering the presently high cost of vacuum tubes, these extra few watts may be very expensive.

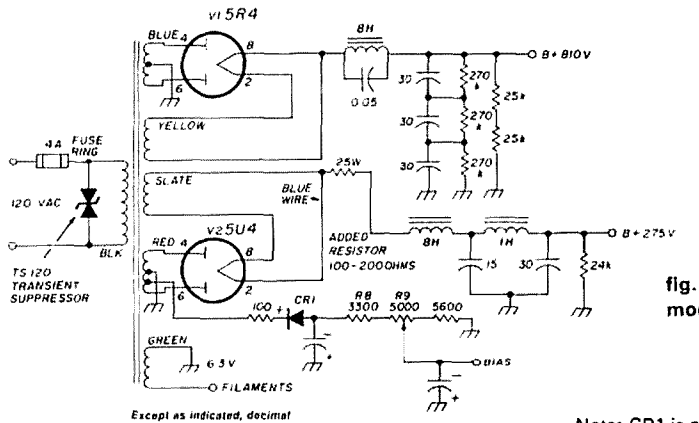
After completing the modification, you may notice that applying high voltage while the equipment is still warm may cause the multimeter to momentarily pin itself. To avoid possible damage to the meter assembly, a silicon meter protector should be installed across the meter terminals. This should consist of a pair of back-to-back 1-amp silicon diodes. These diodes should be chosen to have matching forward voltage drops.

The system including the power transformer will now run considerably cooler, because the two hard vacuum tubes have been eliminated. Also, the filament voltage at the receiving end of the long power cable will be closer to the proper value.

In case you decide to home-brew your own silicon plug-in rectifier units, first consider the actual operating voltages and select the diodes accordingly. A rule of thumb that will keep you out of trouble with a full-wave rectifier is the following: use silicon rectifiers whose PIV (peak inverse voltage) rating is equal to three times the total secondary rms voltage. This rule includes an adequate safety factor if you also include transient protection. In the 516F-2 supply, the rms voltage between pins 4 and 6 of the 5R4 with 120



Close-up of underside showing the rectifier sockets and the new 25-watt resistor mounted on the rear apron.



Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms. k = 1,000 M = 1,000,000

fig. 3. Circuit diagram of 516F-2 power supply with modifications.

Note: CR1 is a selenium rectifier that is subject to aging. It can be replaced with a silicon diode.

IMPORTANT NEWS

hr REPORT

prepared by the editors of Ham Radio Magazi

Number 335

AMATEURS OPERATING 420-450 MHZ in the v
stallations in the Southwest and Florida
FCC at its agenda meeting Wednesday. Act
AMSAT to permit a power increase from th
input in those areas, the Commissioners
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miles radius, were added at Otis Air
and Beale Air Force Base in Californ
areas are described in Part 97.61(b

FCC'S ACTING CHAIRMAN is Commis
earlier predictions. In a just-c
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however point out that, under t
new President's austerity progr
travel, would be severely cut
representation at hamfests or
future! In the memo he also
confirming his role as a car
Reagan's choice is nominate
Mark Fowler Continues to
He's a 39-year-old lawyer
interests, so he knows his
He's also an active Repub
communications matters.
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Top view of Collins 516F-2 power supply before the modification.

volts across the primary is approximately 2,050 volts. Using our rule of thumb, the PIV rating of the silicon rectifiers used to substitute for the 5R4 should be no less than 6,000 volts.

For the low voltage supply, the silicon rectifiers should be rated at 2,500 volts or more. The rule is based on the fact that one diode is conducting while the other is back-biased; this means the back-biased diode sees the full secondary voltage, whose peak value is 1.414 times the rms voltage. We multiply this number by two to provide a safety factor. The safety factor takes into account transients that will exist despite transient protection but which will be reduced in amplitude. Computed in this way, the silicon diodes should last indefinitely.

In summary, this article has defined and dealt with transient protection in a simple and uncomplicated manner. Modification of the Collins 516F-2 has been the subject for modification, but other supplies may be modified in a similar fashion.

Silicon rectifiers are not as forgiving as vacuum tubes. They do not provide early warning by glowing red — they simply die. On the other hand, silicon operates cooler and is more efficient.

The silicon rectifiers in your power supply can last a lifetime if their PIV rating is adequate and if the supply includes transient suppression.

Components needed to make the modification can be obtained from OZ-COMM Co., P.O. Box 685, 803 Seacliff Drive, Aptos, California 95003. Send a self-addressed, stamped envelope for further information.

ham radio

ham radio TECHNIQUES

Bill Orr W6SAI

Happy birthday 10 meters. *March* 7, 1981 marks the fifty-third anniversary of the opening of the 10-meter Amateur band. Can you imagine what Amateur Radio was like in 1928, particularly before the 10-meter band was opened for Amateur communications?

The International Radiotelegraph Conference, held in Washington, D.C., in 1927, set the pattern for Amateur Radio that lasts until this day. Gone were the huge Amateur bands informally assigned in the "*useless*" high-frequency spectrum. In their place were new, narrow bands and a new system of Amateur calls to indicate nationality. Amateur Radio had narrowly escaped the fate recommended by the Canadian delegation to the Conference, "...(I do) not think that Amateurs should ever be given any wavelengths that are known to be useful for any commercial or government communication, and...they should always be obliged to stay within territory...regarded as completely useless...."

From this grim atmosphere Amateur *Radio grew and* prospered.

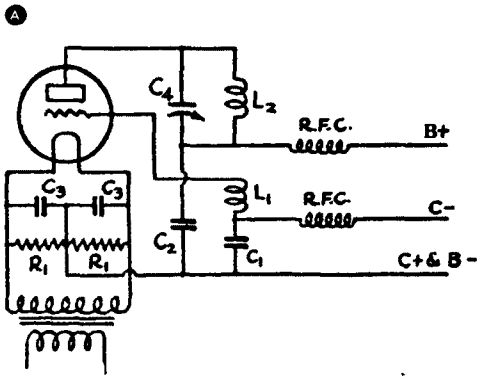
Impossible to see at the time was the future benefit to Amateur Radio of a brand-new band assigned for "Amateur experimental" purposes at 28,000 to 30,000 kilocycles. In the 1928 *QST* editorial discussing the Conference and its immense changes to Amateur Radio, the new "10-meter band" was mentioned only in passing. After all, everyone knew it was a quasi-optical, "line-of-sight" band and probably worthless, otherwise it wouldn't have been tossed to Amateur Radio, as a bone is tossed to a dog.

Of greater concern to the average Amateur was the fact that the 40-meter band had been slashed from 7,000 to 8,000 kilocycles (to 7,000 to 7,300 kilocycles), and the 20-meter band had been severely cut from the assignment of 14,000 to 16,000 kilocycles (to 14,000 to 14,400 kilocycles). How could you cram more than 16,000 Amateurs into bands only a few hundred kilocycles wide?

The February, 1928, editorial in *QST* summed it all up: "We didn't get as *great* privileges as we wanted or as great as we think we were entitled to, but we got all that we were able to, with loyal and powerful assistance from our government. Some of our (ARRL) members do not understand how the attitude of foreign governments could have any effect upon what our government does for us. They forget that radio is an international affair and that it has to be governed by international treaties."

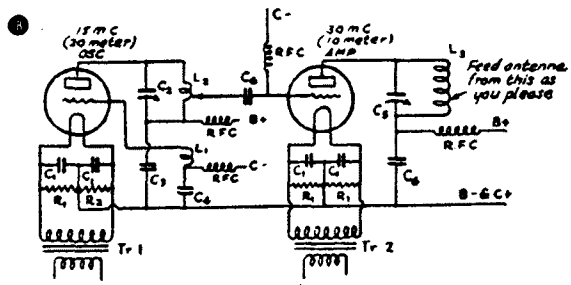
welcome to 10 meters

For several years experiments had been conducted by Amateurs "on the 5 meter wave" of about 50,000 kilocycles (50 MHz). Aside from cranky receivers and erratic transmitters, the band looked promising for short-range work. A few Amateur experimental stations had been given authority to work on 10 meters in 1927, but with dubious results. The new band was a complete blank. And it couldn't be used by Amateurs until April first. The only bright outlook



10-METER OSCILLATOR THAT WILL WORK WELL, AS WILL A LOT OF OTHER KINDS

C1 and C2 Stopping condensers, had better be of mica and with capacity of 200 picos or more.
C3 By-pass condensers. Good if large enough.
C4 100 picos max. will serve.
L1 Cat and try.
L2 One 3" turn of tubing or strap firmly screwed to C4.
R.F.C. 2" windings No. 36 double silk or single cotton on ¼" core.
Feed the antenna from L2 by any method you like.



AN OSCILLATOR-AMPLIFIER TRANSMITTER USING TWO TUBES OF THE SAME SORT WITH THE SAME B AND C VOLTAGES BUT NOT FROM THE SAME SOURCES

There must be a separate B supply at least and it is best to use separate filament transformers. Do not use centertaps on transformers but use resistance centertaps instead as shown.

L1 Cut and try—depends mostly on the tube.
L3 & 2nd L2 One turn copper srip or tube, diameter 3" as a start.
C1 Bypass condcnsers, large enough.
C2 Depends on the tube, 200 picos maximum may do.
C3, C4 and C6 Stopping condensers, must stand plate voltage, plus some r.f. and should have capacity of 200 picos or so.
C5 100 picos max. is enough here.
R.F.C. For the oscillator 3/8" diameter and 2" long with winding of one layer No. 36 double silk or single cotton. For the amplifier reduce diameter winding to ¼". Put the chokes at the job—not a foot away.

fig. 1. A simple oscillator using a UX-210A or 210 tube was suggested as a beginner's transmitter for 10 meters, B. As the caption indicates, specific information was rather sketchy. In B, an oscillator-doubler transmitter provided better stability (it was hoped). No reason was given as to why separate power supplies were *recommended*. Using these circuits, there must have been rf all over the shack! (Drawings reproduced from the May, 1928, issue of *QST*.)*

was that two experimental stations, ef8CT (France) and nu2JN (U.S.A.) had made contact on 10 meters on January 1, 1928. Perhaps the band *did* have DX capabilities (or maybe it was just a freak contact). Only time would tell. As far as was known, only seven Amateurs had been authorized for experimental tests on 10 meters. Plenty of listening had been done but few reports of contacts made.

A small squib in the back pages of April, 1928, *QST* announced the official opening of the 10-meter band. The May, 1928, editorial enlarged upon the new band, commenting, "It is generally thought to be worthless because something happens to waves shorter than 12 or 13 meters, which keeps them from producing useful signals even at the antipodes except under *rare* or freakish conditions. Eminent engineers have told us that the secret of the 10-meter band lies in devising a method of *controlling the angle of radiation*, (italics mine) that if we can find this we will have 10 meters tamed. No more fertile field for the Amateur experimenter was ever offered. Lasting fame and glory awaits the successful."

A few hints were given for getting on the new band.[1] A modest beginner's transmitter circuit was shown in *QST* (**fig. 1**). This one-tube oscillator worked directly on 10 meters. Either a UX-201A or a 210 could be used, depending upon available plate voltage. As you can see, specifications were comfortably vague, and the builder was advised to listen for the second harmonic of commercial radiotelegraph station WIK, which fell close to the center of the 10-meter band. As to the receiver, almost anything would work, it was said. "Just take turns off the *detector coil until* you heard WIK."

10-meter results!

April 1, 1928, was the big day. The first two-way 10-meter contact was between nu6UF (Knowles, California)

*Note the quaint captions on these drawings: one of the many devices that made *QST* so enjoyable in the old days. *Editor, W6NIF*

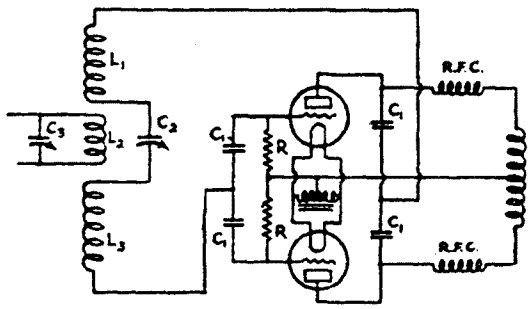


fig. 2. The nu8EX transmitter used for the first two-way 10-meter contact had a pair of 210 tubes in a self-rectified oscillator circuit. Alternating current at line frequency was applied to the plates of the tubes from the transformer at the right of the circuit (secondary only shown). With the low-C tank circuit and ac plate supply, the transmitter note must have been terrible! But it was good enough to do the job. (Drawing reproduced from the August, 1928, issue of *QST*).

FULL-WAVE SELF-RECTIFICATION IS USED BY 8EX WITH THIS REINARTZ CIRCUIT ARRANGEMENT

and nu8EX (Cleveland, Ohio). The whereabouts of the original 8EX is unknown, but 6UF is active, on the air, and a close friend of mine. I called Bill Eitel (W6UF, now WA7LRU) on the telephone and asked him if he still recalled that historic contact. He did, and he told me all about it, and this is what he said, as near as I can recall:

"I remember it all very clearly. I was living in Knowles, California, in the foothills of the Yosemite. There was a big granite quarry in Knowles. All the granite for the Los Angeles city hall came from Knowles.

"One day I got a large, natural, quartz crystal from a creek in the quarry. It was about 8 inches long and 2 inches in diameter. A friend working in the quarry cut it into several rectangles on a stone saw, then I cut it into rough crystal blanks with hacksaw blades and carborundum. From one of the blanks I cut a good 160-meter crystal. It took days of work to get a crystal that oscillated, but I did it. The original crystal was anchored in plaster of Paris so it could be placed into the saw. Once I got a blank, it took many hours of grinding on a plate to make a useable crystal.

"The transmitter began with a type 210 tube oscillator on 160 meters followed by four 210 doubler stages, to 10 meters. Everything was tuned up with a homemade wavemeter. The final amplifier tube was a 203A at first, but I quickly substituted an 852 at about 100 watts input. I had a 10-meter vertical antenna and also a long-wire antenna.

"I remember that 8EX had a 210 oscillator. His transmitter was described in *QST*, (**fig. 2**). He used 60-cycle ac on the plates of the 210s. The signal was very rough. His signal strength was about R6 (S6 to new-

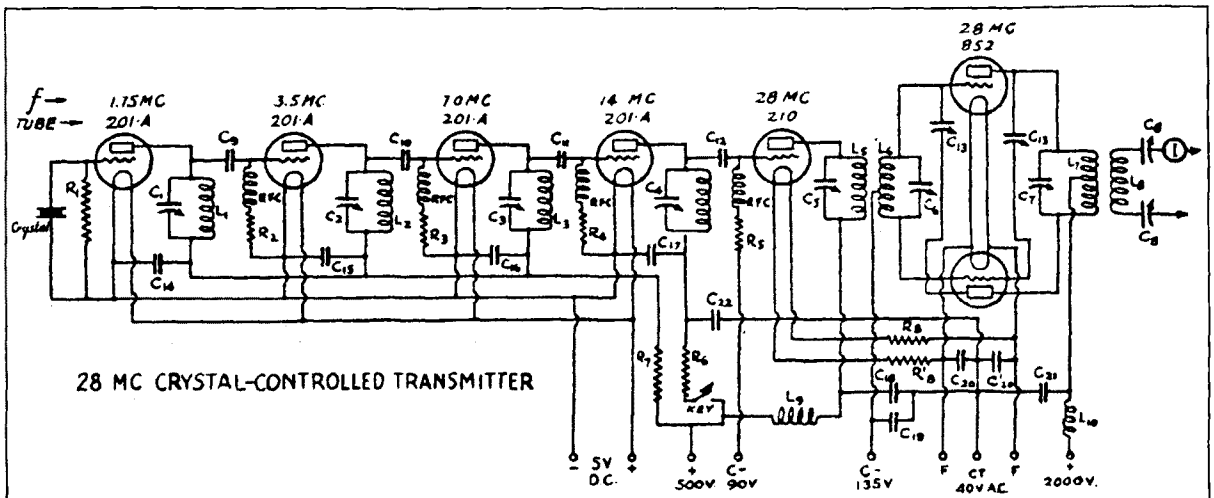


fig. 3. The pace-setting transmitter used for early 10-meter tests at W1XM. Four doubler stages provided 28-MHz excitation from a 1.75-MHz crystal. Because of capacitive coupling between stages, it is surmised that many spurious harmonic frequencies were present at the exciter output. Inductive coupling to the final amplifier (hopefully) eliminated birdies. The nu6UF transmitter resembled this, except that only one 852 was used in the final stage. (Drawing reproduced from the November, 1928, issue of *QST*).

comers), and we were in contact for about an hour.*

"My greatest satisfaction was in tests run later in the year and into 1928 with W1CCZ, on Cape Cod. This beautiful station was a result of work done by the Massachusetts Institute of Technology, by Paul Hendricks and E.C. Crossett, on whose estate the station was located. W1CCZ had a 500-watt transmitter and a four-element Yagi beam — unheard of in those days.

"The W1CCZ beam was unique in that it was movable in *elevation*. It was thought that high-angle signals were the answer to reliable communications on 10 meters. Many tests were run with the beam pointed up at 10 degrees from vertical, which seemed to provide the best results.

"One of the transmitters used in the MIT program operated under the call W1XM (**fig. 3**). My transmitter was somewhat like this, except I used 210s all the way and only a single 852 in the final stage. And I only had 1000 volts for the 852. I never had much luck with that bottle."[2]

interest lags in 10 meters

The year 1929 was a watershed year for 10 meters, as the sunspot cycle was on a rapid decline. Just as things seemed to be picking up and intercontinental DX was on the horizon, the bottom dropped out of the band. Interest lagged, and few signals were heard on 10 meters until 1935, when the sunspot cycle was again on the upswing. The band seemed to come back to life in the fall. The first WAC (Worked All Continents) on 10 meters was made by ZS1H (Union of South Africa). Things were beginning to pay off for a bunch of hardy experimenters, who had remained active on the band over the past three lean years.

QST said, "A band so universally considered dead that early DX work was practically forgotten has suddenly come to life, rewarding in good measure the few who struggled along on it with meagre results."

Worldwide DX conditions led to a flock of WAC certificates, and the first phone WAC was achieved by W6FQY in San Jose, California. Ten meters was alive and kicking!

Seven years had brought about a revolution in *radio transmitting and* receiving equipment. Gone was the regenerative receiver and self-excited oscillator. New crystal-controlled transmitters were available (**fig. 4**), and practical details were available for building a 10-meter rotary beam antenna (**fig. 5**).

getting on 10 meters

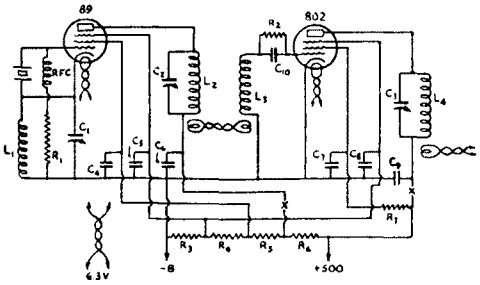
In 1935 I attempted to get on 10 meters. It was a laborious process. I finally got my homemade receiver working so I could hear 10-meter stations. I was amazed at the outstanding signals pouring in from all over the world.

Getting the transmitter on 10 meters, however, was another matter. When it finally seemed to be working, I had no luck at all in working stations I could hear.

Call after call brought no results. Finally, a local Amateur called me on the phone and told me that I had tuned up on the third harmonic of my 40-meter crystal and was on 15 instead of 10 meters! I was loud and clear in a portion of the spectrum in which an Amateur band didn't yet exist!

I soon corrected my error and finally hit the 10-meter band. But I spent several nervous weeks waiting to see if I would get a citation from the FCC for my conduct. Luckily, the 15-meter region was void of any activity, and the FCC probably didn't waste time monitoring the wasteland.

The reappearance of DX on 10 meters was a mystery to most

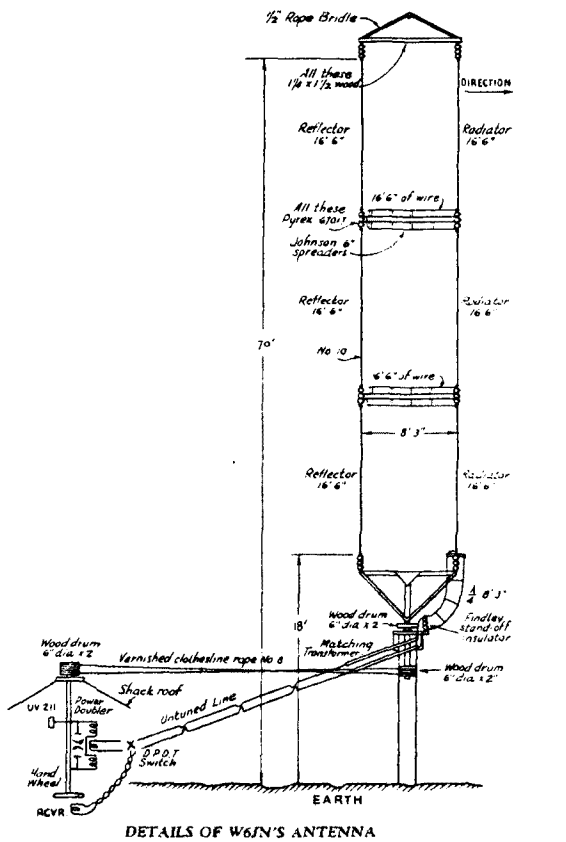


—CIRCUIT OF THE 89-802 LOW-POWER TRANSMITTER OR EXCITER

C_1—365-$\mu\mu$fd. variable (Cardwell Midway, Type MR-365-BS).
C_2—50-$\mu\mu$fd. variable (Cardwell Midway, Type MT-50-GS).
C_3—20-$\mu\mu$fd. variable (Cardwell Midway, Type MT-20-GS).
C_4 to C_9, inc.—.002-μfd. mica condensers.
C_{10}—100-$\mu\mu$fd. mica.
R_1, R_2—50,000 ohms, 1-watt.
R_3—10,000 ohms, 1-watt.
R_4, R_5—10,000 ohms, 10-watt.
R_6—3500 ohms, 10-watt.
R_7—25,000 ohms, 25-watt.
L_1—10 turns No. 14, spaced to occupy winding length of 1⅛ inches.
L_2—10 turns No. 14, spaced to occupy winding length of 1 inch.
L_3—20 turns No. 24 on 1-inch diameter tube, winding length 1 inch.
L_4—7 turns No. 14, spaced to occupy winding length of ⅜ inch. L_1, L_2 and L_4, coil diameter 1⅜ inches. One-turn link on tame tube as L_3, closely coupled to ground end. One-turn link coupled to L_3 made of hookup wire.

fig. 4. This two-tube, 10-meter transmitter of 1936 is modern enough to do a good job on the band today. The 802 pentode amplifier is capable of 40 watts input. A 7-MHz crystal was used. Cathode circuit of the 89 oscillator tunes to about 10 MHz to provide correct feedback. Plate circuit is tuned to 14 MHz, and 802 is a frequency doubler to 28 MHz. (Drawing reproduced from the January, 1936, issue of *QST*.)

*The back-to-back, self-rectified transmitter in **fig. 2** was also popular in commercial circles as late as 1938. I was the chief (and only) operator on a tuna boat working out of San Diego in that year. The transmitter used a pair of UX852 tubes in a circuit almost identical to that shown in **fig. 2** but designed to work on the 36-, 24-, and 18-meter marine bands. The transmitter was enclosed in a SQUARE-D™ switchbox, which was mounted on the bulkhead in the radio shack. Power was supplied from a 500-cycle alternator. Thus the signal wasn't as broad as that from 8EX's rig, which operated from 60-cycle ac; however, it had a good whine and made the coastal stations sit up and take notice. **Editor, W6NIF**



DETAILS OF W6JN'S ANTENNA

fig. 5. One of the first 10-meter rotary beam antennas was used at W6JN. Composed of three half waves in phase with reflectors, the array was suspended from a wooden telephone pole. It probably provided gain equivalent to today's 3-element Yagi. In 1936 when large beams on 10 meters were unknown, it must have been a block-buster! (Drawing reproduced from the April, 1936, issue of *QST*).

Amateurs who had never heard of the sunspot cycle. But in the years before World War II, the band was red hot with DX from all over the world booming in. No doubt the popularity of 10 meters helped fuel the boom in Amateur Radio in the late 1940s. Every stateside DX-minded ham wanted to work the rip-roaring signal of K6MVV (later KH6AR) in Hawaii!

10 meters after the war

November, 1945, was the red-letter day. The FCC announced the restoration of Amateur Radio on the high frequencies. The post-war 10-meter band was from 28.0-29.7 MHz, with phone work, in the United States, from 28.1-29.5 MHz. Frequency modulation could be used above 28.95 MHz. The portion of the old band, from 29.7-30.0 MHz had, regrettably, been lost in the post-war reallocation of frequencies.

Rapidly, 10-meter Amateur stations were popping up all over the world, many of them run by GIs using military rigs. Some of the well-known calls were EA1D (Madrid Airfield), P1X (Holland), W8CJR/XU (China), W6NSL (Japan) and ZC6NX in Palestine.

The U.S. Marine Base at Tsingtao, China, in particular, was very active on 10 meters, with more than twenty XU stations on the air at one time or another.

Rarer DX was there for the sharp-eared DX hunter. W4YA/XZ on the Burma Road was on as well as G6CU/ZC2 on Christmas Island. Also included was Mr. DX himself, Reg Fox, AC4YN, in Lhasa, Tibet!*

the bright new world — of sunspots

Almost unnoticed in the clamor to get back on the air was an historic article in *QST*, which outlined wartime research into hf communications and the sunspot cycle.[3] Research conducted before the war by the National Bureau of Standards and the Carnegie Institute was continued, with greater impetus, during the war by the armed forces. A method of predicting radio conditions, with respect to the sunspot cycle, had evolved.

Amateurs engaged in military communications during the war quickly realized that the frequencies above 20 MHz were capable of long-distance communications. The military fm band, centered at about 35 MHz, opened up day after day for long-distance Pacific DX. Operators in Borneo eavesdropped on communications from Iwo Jima, and shipboard operators on the way to Okinawa were amused by complaints from Ulithi, in the Marshall Islands, that the ship "short range" fm transmission circuits were breaking up local harbor communications. Other transmissions up to 4,000 miles (6,500 km) were noted over various Pacific circuits in the 35-MHz range.

Much of the unusual DX could be explained by the sunspot cycle and solar activity. Propagation studies revealed how much of the 10-meter DX work was possible, and charts were available whereby propagation predictions could be made for the future. Best of all, the sunspot count

*I have AC4YN's card for a two-way contact on 14 MHz dated April 2, 1947. Not for sale. **Editor, W6NIF**

was on the rise, promising great 10-meter DX until at least 1952!

10 meters in the 50s

By 1953 the 10-meter band was back in the doldrums. The sunspot cycle had taken its count, and hams looked elsewhere for DX. W1JPE (now W1DX) summed it all up:

No more about ye DX bands,
Do DXers pushe and pulle,
Or talk about YJs, PKs,
Or toss about Ye Bulle

Ye sunspot count hath gummed ye game
Ye bands are dry as snuffe
And many a hearty soul, no doubt,
Has learned how to do without,
Excepting Thee and Me, Olde Scout,
Who never worked Ye stuffe.

the great sunspot cycle peak of 1957-58

And come back it did! After a few arid years, 10 meters came back to life in the fall of 1955, just as the experts predicted! And again, there was a revolution in equipment on the band; single sideband had arrived to stay. The band had perked up in the spring and was going full blast by fall. As the sunspot count increased and the MUF (Maximum Usable Frequency) continued to rise toward 50 MHz, many 10-meter operators noted that a *too-high* sunspot count could produce ill effects on the 10-meter band, and the *great* sunspot cycle peak in the winter of 1957 didn't seem to produce super-DX on the 10-meter band, although the band remained open until the late evening hours.

DX was good, however, and exotic stations such as JT1AA (Mongolian People's Republic) were present, and Soviet Amateurs showed up on 10 meters in great numbers. And, as it had since the beginning of sunspot measurements by the Chinese before the birth of Christ, the sunspot cycle started its inexorable down turn, reaching a nadir during the winter of 1964.

10 meters today

The period between 1964 and 1976 represents Cycle 20 of the sunspot count, which started with Cycle 1, based on measurements made in 1750. The present Cycle, 21, is at, or near, a peak, and the 10-meter band is alive with activity. This band is expected to remain active and capable of sustaining long-distance communications well into 1986. By then, when the sunspot cycle has dropped to a new low, it's possible that relay satellites may be in orbit to take up the slack. Time will tell.

survey of the 10-meter band area

Meanwhile, a lot can be learned from a close examination of the 10-meter band and its environs. Below 10 meters, ranging from 26.5 MHz to the low edge of 10 meters, is a bewildering mixture of illegal CB operation. By concensus, most out-of-band a-m CB operation occurs between 26.5 MHz and channel 1. From channel 40 up to (and sometimes including) the low edge of 10 meters, the frequencies are chock-full of SSB activity. At times, the QRM is extremely heavy, especially when the channels are open to worldwide communications. A look-see over this range by one unaware of the activity comes as a shocking surprise.

One day last fall, over a period of four hours, I logged over 30 countries on CB, which were operating outside the assigned channels. Stations as far away as Italy and Australia came rocking in, with plenty of callers in the United States!

The 10-meter band itself has a few surprises. During the afternoon hours, the third harmonic of the Radio Moscow home service in the 9-MHz broadcast band is clearly heard on the West Coast. Stations as far inland as Tashkent come through. The stations seem to be spaced about every 100 kHz, starting with a harmonic on 28.0 MHz and running upwards of 28.8 MHz.

Above the top end of 10 meters, *normally* a preserve for Amateur fm from 29.5-29.7 MHz, lie the commercial fm channels extending higher in frequency from 29.7 MHz. However, at 29.705 MHz I could hear a special broadcast station in Israel, beamed to the Soviet Union. The transmitter power was 20 kW and the over-the-pole signal was a good band marker for European openings in the spring of 1980. So far the station has not shown up.

Finally, there is growing activity at the high end of 10 meters as interest in fm grows. The calling frequency is 29.6 MHz, with repeater inputs every 20 kHz below that, to 29.52 MHz. The output channels are 100 kHz higher than the input and fall above 29.6 MHz.

It's an eerie feeling to bring up a repeater on the East Coast from California and work European and South American signals through it. And the hams on the East Coast can work Australia and New Zealand through repeaters in California! Some repeaters have an input on 144 MHz, and it's common to hear hams on 2 meters working DX on 10 meters through a repeater while walking around with a handheld rig.

And so it goes. The 10-meter band has come a long way from the early days when nu6UF opened the band with his historic QSO. A salute, then, to 10 meters and happy birthday! Here's to more and better 10-meter activity until old sol takes over the band sometime in 1986. I'll see you on Ten!

references

1. Kruse, "Getting Started at 30 Megacycles," *QST*, May, 1928.
2. I wonder if the trouble Bill Eitel had with the 852 influenced him to go into the tube business in a few years! Bill and Jack McCullough, W6CHE, were instrumental in designing the HK-354 transmitting tube at Heintz and Kaufman Company in the early 30s. Then they went on to found Eitel-McCullough, Incorporated, the manufacturer of the famous EIMAC power tubes.
3. Conklin, "The Bright New World of Sunspots," *QST*, January, 1946. (Bill Conklin, then W3JUX, is now licensed as K6HA).

ham radio

X-band calibrator

How to get started on the 10-GHz Amateur band

This article describes a frequency calibrator for use with Amateur X-band transceivers such as the Microwave Associates Gunnplexer®. The calibrator is simple to build and makes communications over long-haul, non-optical paths easy to accomplish.

the Gunnplexer

The Microwave Associates Gunnplexer is a great device with which the Amateur can explore the challenging frontier of microwaves. The Gunnplexer includes a Gunn-diode oscillator, which is used for both the transmitter and receiver local oscillator. A Schottky diode and ferrite circulator are used as the receive mixer (**fig. 1**). A varactor diode mounted in the Gunn-diode oscillator cavity provides approximately 100 MHz of transmit and receive tuning variation (plus frequency modulation). All that's required for operation is 8 or 10 Vdc for the Gunn-diode,* 0-20

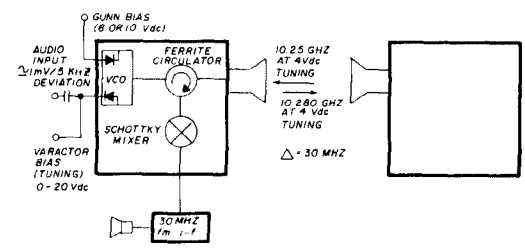


fig. 1. The Gunnplexer consists of a Gunn-diode oscillator, which serves as both the transmitter and receiver local oscillator, and a Schottky diode and ferrite circulator which are used as the receiver mixer.

*Some units require 8 Vdc and some 10 Vdc. The required voltage should be marked on the unit.

By Steve J. Noll, WA6EJO, 1288 Winford Avenue, Ventura, California 93003

Vdc for varactor tuning, and an fm receiver for the i-f. Audio is coupled into the varactor for modulation. The i-f is 30 MHz.[1]

Gunnplexers have been available in pairs set to the standard split of 30 MHz. One unit is mechanically tuned so that, with 4 Vdc of varactor bias (tuning voltage), the Gunn-diode oscillator output is 10.280 GHz. The second unit is similarly set to 10.250 GHz with 4 Vdc bias. The difference of these two frequencies is the "standard" i-f of 30 MHz.

The tuning range of a typical 10.250-GHz Gunnplexer is approximately 10.22 to 10.32 GHz. A typical 10.280-GHz unit covers approximately 10.25-10.35 GHz. These are the Gunn oscillator frequencies, so the receive frequencies will be 30 MHz above and below.

the problem

Two problems become apparent after one has had some experience with the units over long paths. One is aiming the antennas when the location of the other unit is not precisely known. Eventually the operator graduates from the basic 17-dB horn antenna supplied with the Gunnplexer to high-gain parabolic reflectors. With high gain comes narrow beamwidths; that is, about 2-1/2 degrees for a 3-foot (1-meter) dish and 1-1/4 degrees for a 6-foot (2-meter) dish. This certainly can make aiming over non-optical paths very difficult.

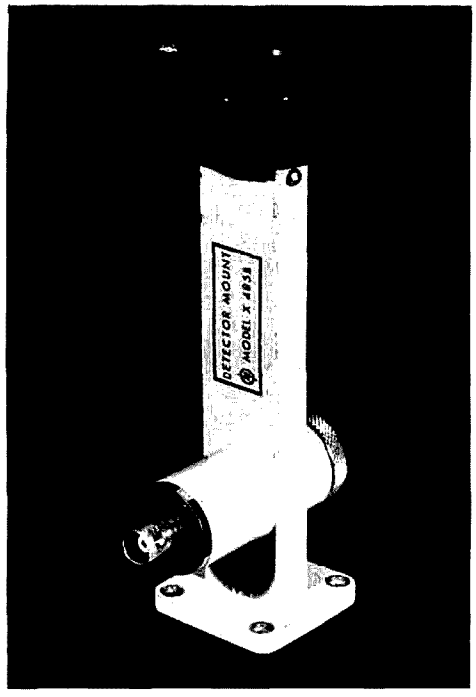
The second problem is finding the signal. This problem can be worse than the first, especially when the signal is weak. The 100 MHz of tuning is quite a bit. You can easily tune by a weak signal even when ten-turn pots are used for tuning. Narrow i-fs that are used to increase range add to the problem. It is desirable to have the full 0-20 Vdc tuning range available to be compatible with any other person's Gunnplexer; that is, to be sure to be within his tuning range.

These two problems of aiming and tuning are definitely additive. They make an attempt at a long-distance contact a formidable task. However, solve one problem and the other becomes much easier.

the solution

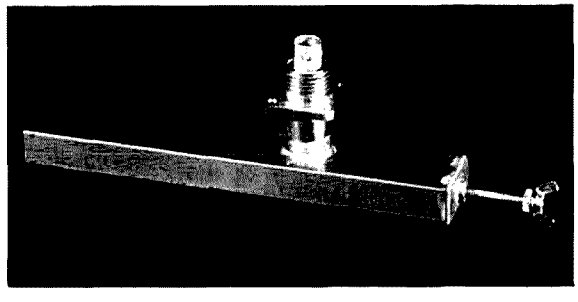
The use of compass and map will get you in the ballpark on aiming, but usually not right on. Frequency calibration would solve the tuning problem. An X-band frequency counter would be nice, and also unaffordable — especially insofar as one would be required at each end of the path. An X-band crystal-controlled multiplier chain with perhaps a Snap diode output circuit would do the trick too. But it would also be a trick to build.

All hope is not lost, however. There is a very simple and inexpensive way to solve the problem using the crystal-controlled multiplier chain approach.

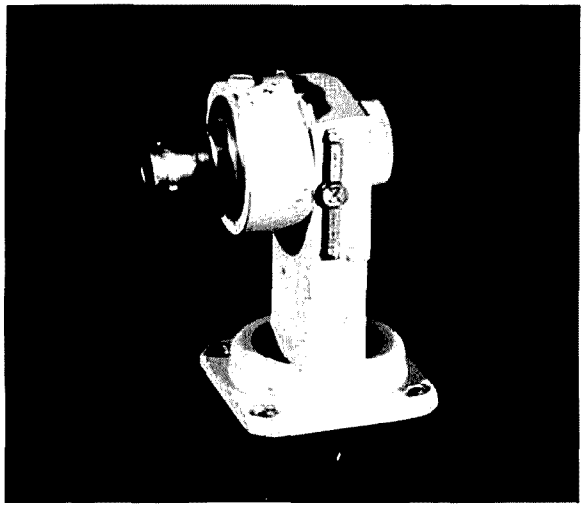


HP-X485B tunable detector mount.

If one feeds some relatively low-frequency rf into a common microwave mixer diode, such as a 1N23, all sorts of things will come out: a comb, of sorts, is generated. The objective in this case is to get a detectable output in X-band within the tuning range of the Gunnplexer. Too many outputs within the tuning range can lead to confusion, however. One or two are sufficient. A single-output crystal calibrator would not be all that helpful. With it you could tune two Gunnplexers exactly on the same frequency, but that's not what you want. A 30-MHz difference is needed between the two units. Two stable calibration signals are desired: one within the tuning range of each Gunnplexer but also 30 MHz apart from each other.



Tunable waveguide diode mount with TWT or BWO N connector.



DeMornay Bonardi waveguide detector mount.

the calibrator

Luck is with us. It just so happens that if you pump 146.52 MHz into a microwave mixer diode (in a suitable mount) you will get a 70th harmonic output of 10.2564 GHz. This is well within the tuning range of the 10.250-GHz Gunnplexer and is probably within the tuning range of the 10.280-GHz unit. The 69th harmonic (10.10988 GHz) and the 71st harmonic (10.40292 GHz) are outside the tuning ranges of both Gunnplexers. This eliminates any possible confusion due to more than one calibration signal within the tuning range.

Most Amateurs should have no trouble coming up with a signal on 146.52 MHz. But we still need another signal in X-band 30 MHz away from the 70th harmonic of 146.52 MHz.

Luck is with us again. Another 2-meter fm frequency which is common in some parts of the U.S. will give us a signal fairly close to that which is needed. 146.94 MHz x 70 equals 10.2858 GHz, a 29.4 MHz difference from the 146.52-MHz harmonic. Two Gunnplexers calibrated to these signals would be tuned 29.4 MHz apart. A slight touch of the tuning knob would correct the 600-kHz error. That's not much of an error at X-band!

This small error can be reduced or eliminated completely by one of several methods. If a crystal-controlled 2-meter handheld is being used, a crysal can be ordered on 146.94857 MHz for use with a standard 146.52-MHz crystal. If your handheld has both .52 and .94 crystals in it already, they could be tweaked so that they are the required 0.4285714 MHz apart at 2 meters to be 30 MHz apart at X-band *(70 x 0.4285714 = 30)*. Synthesized radios set at 146.515 MHz and 146.945 MHz would result in only a 100-kHz error at X-band. And of course, a VFO-controlled radio could be set at the desired frequencies too.



PRD 613M coaxial mount with waveguide-to-N adapter.

the diode multiplier

So far we have a simple source of rf that will give us the signals needed at X-band when suitably multiplied. Now comes the tricky part, right? Wrong! A diode multiplier is amazingly easy to build, but first let's consider some of the readymade choices: waveguide detector mounts and coaxial detector mounts.

Waveguide detector mounts work best. That is, they can put out a rather strong signal at X-band when 2-meter rf is fed into what is normally the output connector. A Hewlett-Packard X485B is a tunable X-band detector mount that accepts 1N21-1N23 type diodes, the latter being preferred. A mount that uses these inexpensive field-replaceable diodes, or crystals as they're often called, is very desirable. It is possible to burn out the diodes as a result of applying too much rf. The 1N21-1N23 series diodes has a maximum incident CW rf power rating of 250 mW.

The Hewlett-Packard 423A is a common coaxial mount that works fine as a multiplier. The 2-meter rf is fed into the BNC connector that is normally the output connector. A waveguide-to-N connector adapter affixed to the mount's N connector serves as the X-band antenna. Note that the diode element is not the easily replaceable 1N23 type, so due care

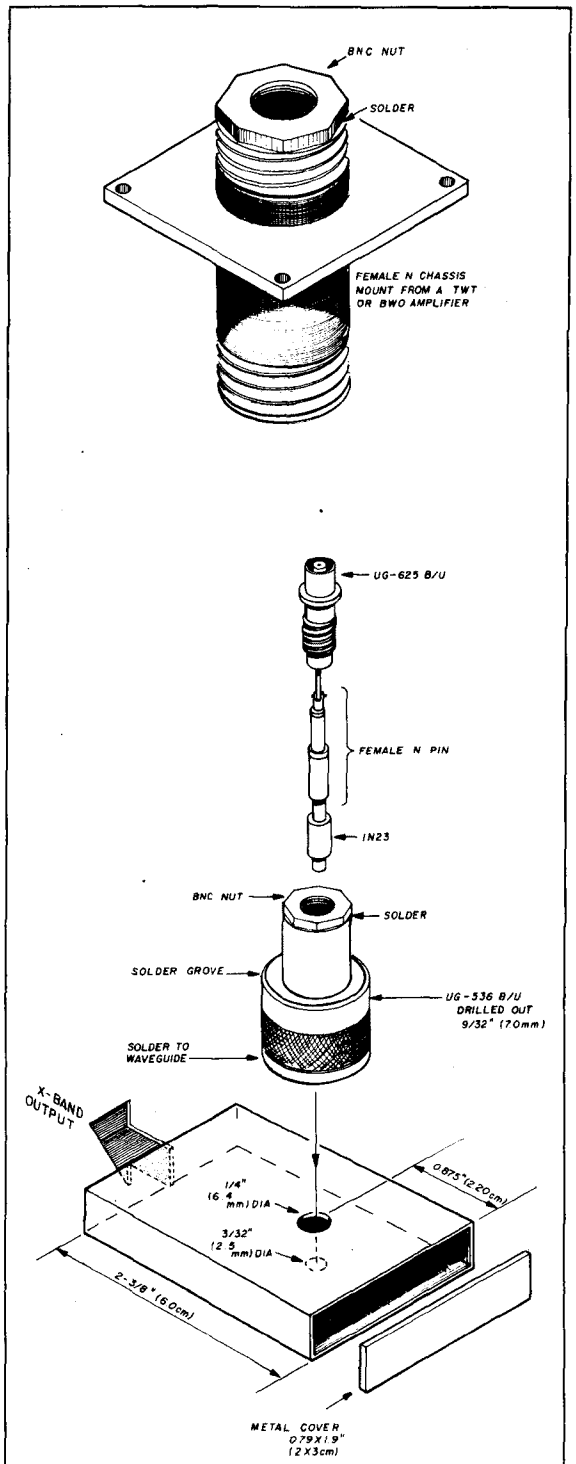


fig. 2. Simple X-band waveguide amplifier mount uses WR-90 waveguide and BNC connectors modified as shown. An alternative female N chassis mount may be made from a TWT or BWO amplifier. No need to drill out the connector in this design.

should be exercised!

A PRD 613M is a coaxial crystal mount with an easy-to-replace diode. It does not have nearly the output of the HP coaxial mount but is usable.

Many other mounts will also work. Each of the above-mentioned mounts was obtained on the surplus market for about $20. 1N23 diodes are very common in surplus microwave equipment and are available from surplus outlets such as Fair Radio Sales Co.* for about $1 each.

A diode in a package with a pin on each end is needed for the homebrew mounts. Some diodes have a cap on one end. Be sure to get the diode with a removable cap (it just pulls off); some diodes have non-removable caps.

building a waveguide diode mount

I've built several mounts, both waveguide and coaxial. Precision machining is not required. A hacksaw, file, propane torch, drill, and two bits are the only tools needed to make a waveguide mount. The materials required are, first, a few inches of brass or copper X-band waveguide. Such waveguide is designated WR-90, RG-52U, or WG-16. It measures 1 x 1/2 inch (2.54 x 1.26 cm) outside dimensions. This may be found surplus or from an outlet such as Lectronic Research Laboratories, Inc.† A small piece of PC board or other solderable flat metal is needed to close one end of the waveguide. A one-hole mounting BNC female connector (UG-625B/U) serves as the 2-meter rf input connector. A female chassis mount N connector supplies the center pin, which holds the 1N23 diode. A male N connector of the type that accepts small (RG-58/59) coax (UG-526B/U) or a female chassis mount N connector removed from a surplus BWO or TWT amplifier serve as a fixture to hold the BNC connector assembly to the waveguide.

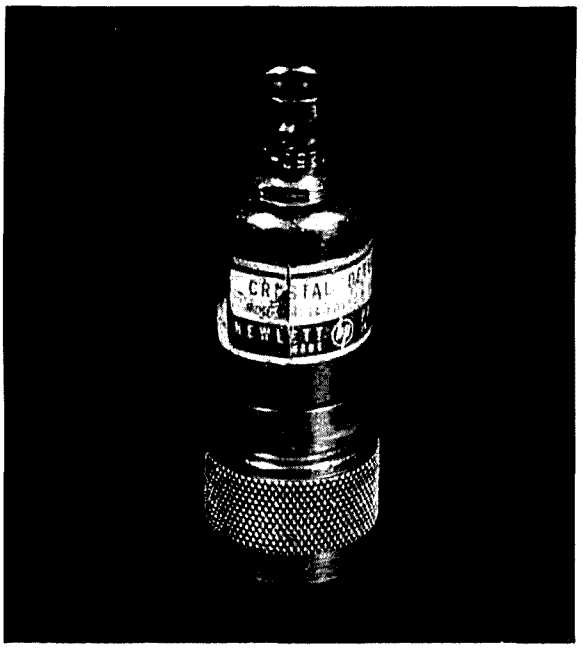
A horn antenna may be built on the open end of the waveguide, or a flange may be affixed there for the attachment of a horn. This will give greater range, but it's not necessary. A Gunnplexer will hear the signal from a waveguide mount multiplier without a horn from several feet away.

construction

Cut a piece of waveguide 2-3/8 inch (6-cm) long or longer (refer to **fig. 2**). The length is not critical. File the ends square and remove any burrs. Drill a hole with a 3/32-inch (2.5-mm) bit in the center of the wide side of the waveguide 7/8 inch (2.20 cm) from one end. This is the only critical dimension. Drill this

*1016 E. Eureka Street, P.O. Box 1105, Lima, Ohio 45802.

†Atlantic & Ferry Ave., Camden, New Jersey 08104.



HP-423A coaxial mount.

hole straight through both walls of the waveguide. One of these holes serves as the socket for one end of the diode; the other hole is the pilot hole for the next one. Drill a 1/4-inch (6.4-mm) hole through the pilot hole. Remove the burrs inside the waveguide with a small triangle file. Clean the area around the 1/4-inch (6.4-mm) hole with sandpaper.

If you're going to use a male N connector (UG-536B/U), remove the loose gasket, washers, and nut. They will not be needed. Drill a 1/4-inch (6.4-mm) hole straight through the connector to enlarge the existing one. Remove any burrs. If a connector from a BWO or TWT amplifier is used, it will not be necessary to drill a hole, as the existing hole is large enough (**fig. 2**).

Center the connector face down over the 1/4-inch (6.4-mm) hole. Solder the connector to the waveguide, using a propane torch. Also solder the groove on the male N connector so that the connector body will no longer rotate. Let the assembly cool.

Next lay a one-hole-mount BNC nut on the top of the N connector, centered over the hole that the coax normally enters. Solder the nut to the connector, taking care not to get solder in the nut threads.

A piece of PC board or sheet metal 3/4 x 1/8 inch (2 x 3 cm) is then soldered over the open end of the waveguide closest to the N connector.

Heat the center pin of a female chassis-mount N connector, such as a UG-58/U, until it can be pushed out of the plastic dielectric.* Alternatively, the center pin of Teflon dielectric N connector can be easily driven out with a hammer and pointed tool. Solder center pin to the protruding center pin of a one hole-mount BNC female connector (the slotted end of the pin faces outward).

It's now possible to push one pin of the mixer diode into the slotted pin on the BNC connector. Push the diode pin in about 1/16 inch (2 mm). Guide the protruding diode through the hole in the N connector into the waveguide. The diode pin is mated with the 3/32-inch (2.5-mm) hole as the BNC connector is screwed into the BNC nut. Tighten *finger-tight* only.

It may be necessary to adjust the length of the slotted pin if the same type of connectors weren't used and the diode doesn't seat properly. The X-band waveguide diode mount is now complete.

simple coaxial diode mount

I've devised a coaxial diode mount that has to be one of the simplest ever (**fig. 3**). It is actually closer to a waveguide mount in the way it operates. All that's required is a female uhf barrel adapter (PL-258) or an N barrel (UG-29B/U), a shell from a PL-259, a

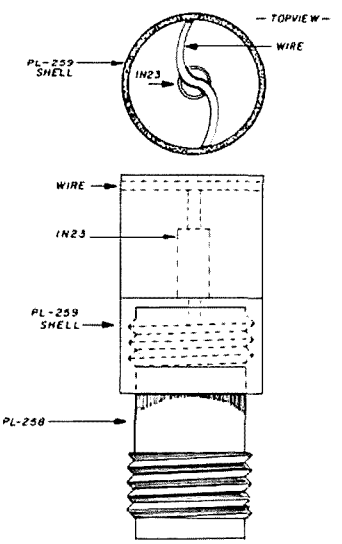


fig. 3. This coaxial diode multiplier mount is made from a female uhf barrel connector or an N barrel (UG-29B/U), a shell from a PL-259 connector, a piece of bare copper wire, and a 1N23 diode — simple and effective.

*Use caution in this operation. You can ruin connectors by applying too much heat. The idea is to apply heat to the N connector by waving the heat source (propane torch) back and forth over the connector while gently applying pressure to the dielectric material. At the right moment, the dielectric and center pin will pop out of the connector. Use too much heat, and you must go back to square one and start over. **Editor.**

15/16-inch (24-mm) piece of No. 12 AWG (2.1-mm) bare copper wire, and a 1N23 diode. Soldering is optional.

If an N barrel is used, push one pin of the diode 1/16 inch (1.2 mm) into one of the slotted pins of the barrel. If a uhf barrel is used, simply lay one end of the diode into one end of the barrel. Be sure that the metal end of the diode contacts the barrel pin. In some PL-258 models, the center pin is recessed enough so that the dielectric prevents contact.

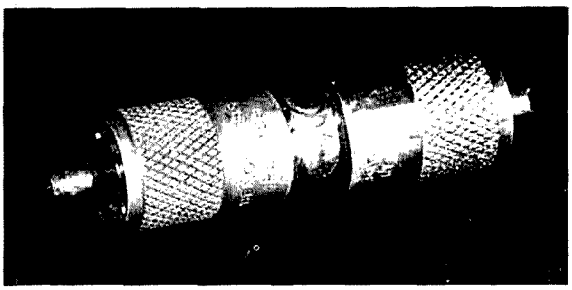
Bend the wire into a Z shape so that it will lie inside the uhf connector shell with the ends resting on the shoulder. The shell is started once the barrel threads with the diode are in place. Hold the wire with needle-nose pliers inside the shell over the diode pin. Tighten shell to push the wire down onto the pin of the diode (the wire ends may be soldered to the shell shoulder if desired). The 2-meter rf input is connected to the other end of the barrel. If a barrel adapter isn't available, a female chassis mount connector may be used. The 2-meter rf input is then brought into the back of the connector through a coax cable.

numb i-f response

At this time, if your Gunnplexer and/or i-f is "numb," you may not be able to hear signals from any of the diode mounts described. A numb Gunnplexer is not uncommon. The Schottky diode mixer is easy to zap with stray voltages. Soldering to the *ungrounded* mixer connection pin, even with so-called "grounded" soldering stations, is a sure way to put your mixer diode in peril. The Schottky will not necessarily be completely open or shorted — it can remain halfway between and just be numb. Don't fret. If you blow it, just replace the Schottky diode with a 1N23. (I've measured less than 1-dB noise figure degradation by substituting a 1N23WE for the standard Schottky.)

A numb i-f will also cause problems. Try to make the stage as hot as possible in the noise-figure department. This is one of the few ways to improve the over-all sensitivity of the Gunnplexer. It may be necessary to run the 2-meter level into your diode mount near the maximum 250-mW level until improvements can be made in your system.

I've been able to detect the X-band output of the homebrew 1N23 coaxial multiplier using a Gunnplexer with a 17-dB horn at a distance of 1 foot (30 cm) with a 2-meter drive level as low as 10 mW. The range of the same setup using 250-mW drive was over 50 feet (15 meters). This was a "hot" Gunnplexer and i-f. I was able to measure at least 2 dB of sun noise with a 2 1/2-foot (76-cm) dish.



Attenuator.

attenuator

Whatever mount you choose, surplus or homebrew, an attenuator will be required to reduce the output of the 2-meter transmitter to a safe drive level. A 6-dB pad will decrease a 1-watt signal to 250 mW. A 10-dB pad will yield 100 mW — a good choice.

A power attenuator isn't necessary, as the power-handling ability of an attenuator is greatly increased if power is applied for a short duration. A 1/2-watt pad is fine for intermittent use at power levels encountered in 2-meter handheld transceivers.

As with detector mounts, attenuators are available on the surplus market or can be homebrewed. If you have a surplus pad in mind, be sure it's 50 ohms and that it will work at frequencies as low as 2 meters.

building an attenuator

A pi-network resistive attenuator requires only three resistors and is easy to construct. A table of attenuation levels and the required resistor values may be found in the ARRL *Electronics Data Book*.

I've built a 10-dB pad using two 1/2-watt, 100-ohm resistors and a 1/2-watt, 68-ohm resistor, plus two PL-259 connectors. Actually, a 10-dB pad requires 96.2-ohm and 70.7-ohm resistors, but the standard values I use yielded 9.5 dB with excellent VSWR. Construction details are shown in fig. 4.

calibrator system operation

The diode multiplier mount is connected through the attenuator to a 2-meter transmitter set at 146.52 or 146.94 MHz. The mount is pointed at the Gunnplexer antenna, and the varactor voltage is tuned until the calibration signal is found. You'll probably hear a loud audio feedback squeal when the signal is found.

Talking into the 2-meter rig should result in a copyable signal from the Gunnplexer receiver. It may be hard to believe, but you're actually talking on X-band with your 2-meter rig! Be sure to ID properly.

Mountaintop operation might go like this: **Station A** lets his 10.250-GHz Gunnplexer warm up a few minutes, then he tunes it to find the signal from his

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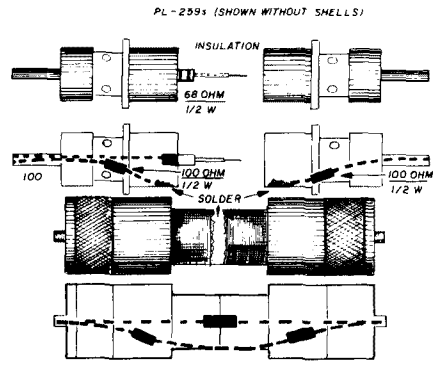


fig. 4. A 10-dB attenuator, again made from coax connectors. Three resistors form a pi network.

diode-mount, which is fed with a 146.52-MHz signal. (The mount is held several feet in from of the Gunnplexer antenna to avoid frequency pulling of the Gunn oscillator.)

Station B, on another mountaintop, does the same with his 10.280-GHz Gunnplexer using 146.94 (or 146.94857 MHz.) The two stations then may concentrate their efforts on aiming, varying their varactor voltage only 100 mV or so. Extra 2-meter handheld transceivers help establish communications.

The stations must be sure ahead of time that their respective Gunnplexers (a) will tune to, and hear, the calibrator signals, and (b) are *not* tuned to the signal image.

other uses

The calibrator does not, of course, have to be used only on .52 and .94 in the 2-meter band. The Gunnplexer may be calibrated throughout the 0-20-Vdc tuning range by selecting other 2-meter frequencies that will multiply into X-band.

The diode multiplier mount may also be used as a detector mount. I can measure well over 1 volt across the diode when either homebrew waveguide or coaxial mount is irradiated by the Gunnplexer output at close range. This is a very easy way to check the mount and the Gunnplexer oscillator.

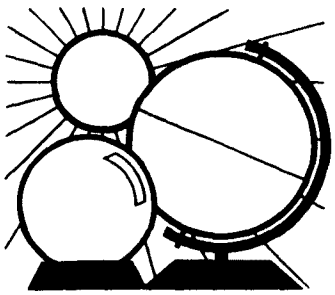
acknowledgments

I'd like to thank WA6HCD and WA6IKO for their help in my X-band endeavors, as well as W6OAL for reviewing the manuscript.

reference

1. James R. Fisk, W1HR, "10-GHz Gunnplexer Transceivers — Construction and Practice." *ham radio*, January, 1979, page 26.

ham radio



DX FORECASTER

Garth Stonehocker, KØRYW

last-minute predictions

April is a transition month. Propagation will be affected by solar activity that is influenced by the equinox period of sun/earth alignment (as mentioned last month). The periods from April 7 through April 14 and April 20 through April 23 may be geomagnetically disturbed. The beginning of the first period is expected to be disturbed by coronal-hole solar-wind emergence, then by solar-flare-released particles for the remainder of the first time period and for the entire second time period. The effects may be strong, since April is a continuation of the equinox period. However, the coronal-hole effect will not be as strongly developed as it will be a year from now, so the probability is not high that this disturbance will occur.

DX conditions will probably be very good in April because of the solar-cycle level, and activity will be high because of the close proximity of the equinox season. The ionosphere is proportioned for most of the ionization to favor the F region and high maximum usable frequencies (MUF) — therefore the higher hf bands. The winter generally has the sharpest daily MUF peaks, rising highest in February, March, or April in most years. Summers have the lower daily MUFs but are spread out throughout the greater number of hours of daylight. So, through this summer and next winter, the solar flux will probably be slightly lower than it is now. And it is then expected to continue to decrease as the end of the crest of cycle 21 begins a definite downward trend toward the minimum, about 1987.

band-by-band forecast

Six meters should provide frequent band openings with a peak during the early afternoon hours on many days. Trans-equatorial north-south paths will be the best. Your guide to possible openings will be strong openings on 10 meters and high values of solar flux.

Ten and fifteen meters will be loaded with good DX signals from morning until early evening hours almost every day. Times of geomagnetic disturbance will limit the number of signals heard, but listen carefully — they can be from very unusual places. Fifteen meters should be open later in the day than 10 meters. So, hit 10 first and finish off with 15. The lengthening of the daylight will be noticed as these bands open up a little sooner and stay open longer in the day.

Twenty meters will be the main daytime DX band, as it is almost always open to some part of the world. It opens to the east as the sun rises and extends into the late evening hours to the west. Geomagnetic disturbances do not affect the band as much as the higher ones, but still look for unusual trans-equatorial DX locations to be coming through once in a while. One-hop trans-equatorial DX of 5,000 to 7,000 miles (8,000 to 11,200 km) may be possible in the late evening hours during some of these unusual conditions.

Forty and eighty meters will have much short skip (750 miles or 1,200 km) during daylight hours and turn to DX after dark. Eighty-meter DX will more often be taken over by noise. Therefore, 40 meters will become the best nightime DX band. Long skip (2,000 miles or 3,200 km) will open to the east soon after sundown, swing more to the south to Latin America about midnight, and end up to the Pacific areas during the hour or so before dawn. Some nights these bands will be as good as during the winter DX season. Watch the spring storm fronts mentioned last month. The coastal regions usually have the edge for working the rare DX on these bands. Don't let that stop you mid-U.S.A. DXers.

One-sixty meters will probably have many nights that remind one of last summer's noise. However, many good nights are left to work DX before this summer's noise comes to stay. Many stateside stations are fair game as DX on this band during this season.

ham radio

GMT	PST	WESTERN USA N	NE	E	SE	S	SW	W	NW	MST	MID USA N	NE	E	SE	S	SW	W	NW	CST	EST	EASTERN USA N	NE	E	SE	S	SW	W	NW
0000	4:00	10	15	10	10	10	10	10	15	5:00	15	20*	10	10	10	10	10	15	6:00	7:00	15	15	10	10	15	—	10	10
0100	5:00	10	20	10	10	10	10	10	15*	6:00	15	20	10	10	15	10	10	10	7:00	8:00	—	15	10	10	15	15	10	15
0200	6:00	10	20	10	10	10	10	10	15	7:00	15	20	15	10	15	15*	15*	10	8:00	9:00	—	20	15	10	15	15	10	15
0300	7:00	10	20	15	10	10	10	10	15	8:00	15	20	—	10	15	15	15	10	9:00	10:00	—	20	—	15	15	15	10	10
0400	8:00	10	15	20	15*	15	15	10	15	9:00	15	20	—	10	15	15	15	15	10:00	11:00	20	20	—	15	20	20*	15*	10
0500	9:00	15	15*	20*	15	15	15	10	15	10:00	20*	20	—	15*	20	15	15	15	11:00	12:00	20	20	15	15	20	20	15	15
0600	10:00	15	15	20	15	15	15	15*	15	11:00	20	20	15	15	20	20*	15	15	12:00	1:00	20	20	15	15	20	20	15	15
0700	11:00	20*	20*	20	15	20	15	15	20*	12:00	20	20	15	15	40*	20*	15	20*	1:00	2:00	—	20	20	20	20	20	15	20
0800	12:00	20	20	20	20*	20	15	15	20*	1:00	—	20	20	15	40*	20*	15	20	2:00	3:00	—	20	20	20	20	20	15	20
0900	1:00	20	20	20	20	20	20	20	20*	2:00	—	20	20	20	40*	20	20	—	3:00	4:00	—	20	20	40*	20	40*	20*	—
1000	2:00	20	20	20	20	40*	20	20	20	3:00	—	20	20	20	40*	40*	20	—	4:00	5:00	—	15	—	20	20	40	20	—
1100	3:00	20	20	—	20	40*	40*	20	20	4:00	—	20	—	20	20	40*	20	—	5:00	6:00	20	15	—	20*	20	40*	20	—
1200	4:00	20	20	—	20	40	40*	20	—	5:00	20	20	—	20	20	40*	20	20	6:00	7:00	20	15	20	15	—	40*	20	—
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1800	10:00	15	15	15*	10	—	15	—	15	11:00	15	15	15*	10	10	15	—	15	12:00	1:00	—	15	10	10	—	15*	—	—
1900	11:00	15	15	15	10	10	15	—	15	12:00	—	15	15*	10	10	10	—	15	1:00	2:00	—	15*	10	10	15	15	20	20*
2000	12:00	15	15	15	10	10	10	—	15	1:00	—	15	10	10	10	10	15	15	2:00	3:00	—	15	10	10	10	15	15	15
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2300	3:00	10	15	15	10	10	10	10	15	4:00	15	15	10	10	10	10	10	15	5:00	6:00	15	15	10	10	10	—	15*	10
	APRIL	ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN		ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN			ASIA FAR EAST	EUROPE	S. AFRICA	CARIBBEAN S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN

Questions and Answers

where in the world?

I have heard stations on the air signing "----/MM region 1," How do you know where to aim your beam for the various regions? Is there a map available? — John Engelien, N2BSD.

Almost any publication that includes the FCC Rules and Regulations, part 97 (Amateur Radio Service) has a map showing all three ITU regions. A reproduction is shown in **fig. 1.**

six meters

I hear very little about the 6-meter band, except stories about TVI and other problems. Is 6 meters the "black sheep" of the radio frequencies? Is it dependable for medium to long distances, and what is the dominant mode? — Peter Eldredge, KA1FJN.

Six meters is avoided in many areas of the country, especially near the large cities that have Channel 2 TV. Most TV sets cannot tell the difference between a 50-MHz signal and a 56-MHz one, so TVI is a real problem. (The problem can be resolved, but requires much effort in building filters, cleaning up rigs, and often much education of your neighbors — some hams figure it isn't worth the trouble.) Then, too, Channel 2 TV transmitters put out a lot of garbage below their allocated band, and that gets into Amateur receivers and further discourages any would-be DXers.

However, if Channel 2 is not available locally, then 6 meters can be a fascinating and useful band. It behaves much in the same manner 10 meters does, with good local coverage by ground wave in the evening. And often tropospheric and ionospheric skip creates openings that can reach to hundreds or thousands of miles. Like 10, however, the band varies with the sunspot activity, so will be less prone to DX openings in four or five years than it is right now.

Modes in use are principally CW and SSB on the low end, with a few of the "a-m forever" crowd around 50.5 MHz or so, and fm and repeaters in the upper two-thirds. There is a considerable amount of model-control activity to be found on the high end, using channels that fit nicely between repeater slots.

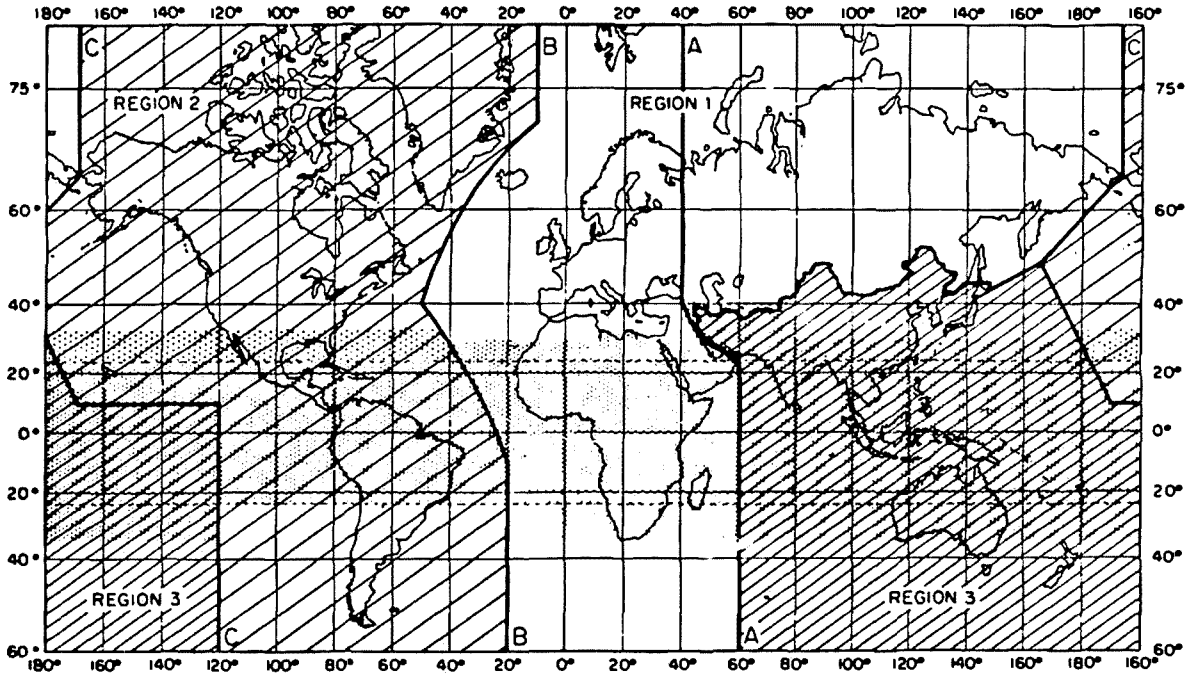
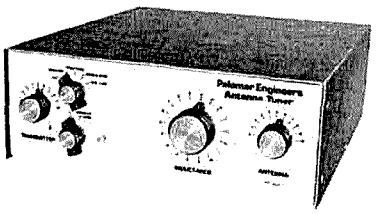


CHART OF ITU REGIONS

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no DX?

We have recently hit the peak of the sunspot cycle, and DX is great. What does the future look like for DX? Will there be any good DX to be found, and if so, on what bands? How about the new bands we got at WARC 79? — Kevin Foley.

DX will continue to be good for some time to come. True, we passed the peak in 1979, but it doesn't all stop abruptly. The downward slope of a sunspot cycle is gradual and filled with small bumps and ripples. DX conditions will decrease in the same manner. There will be excellent days, and dismal days, and it will keep our DX Forecaster on his toes predicting which will be which.

The openings will become a bit shorter, so you will have to be alert and ready to catch the good ones. Also, the openings will tend to become less frequent on the higher bands, but there'll always be something on 80, 40, and 20. Even 15 meters will have good activity for some time. Ten is good for two or three years before you'll notice much of a drop in openings.

The new bands will show a similar pattern, with the lowest one (10 MHz) being more reliable than our present 14 MHz, and the higher ones opening later and closing earlier. However, one of the most useful things we Amateurs can do with the new bands is to "fill in the gaps" in knowledge of propagation by careful observation and use of 10, 18, and 24 MHz.

So, don't despair. Good equipment and sharp operating skills will pay off during times of low sunspot activity.

remote SWR?

VSWR-meter instruction books say that SWR should be measured at the antenna because the coaxial cable can alter the readings, giving a better indication at the transmitter than actually exists at the antenna.

Since I use a matchbox, should I remote the SWR-sensing unit to the antenna for better accuracy? — Terry J. Taylor, WB5JFM.

To put it bluntly, NO!

Presumably, the matchbox is in your radio room, where you can reach the controls. If you were to put the SWR meter at the antenna it would see no change at all, no matter what you did to your matchbox (except to show wild fluctuations because there was more or less power getting through the matchbox).

For example, suppose you are using 50-ohm coax cable and the SWR meter is at the antenna. Also suppose the antenna is not properly adjusted (too long or too short). No amount of knob twisting on the matchbox will make any difference at the antenna. The 50-ohm cable still presents 50 ohms to the matchbox down in the radio room.

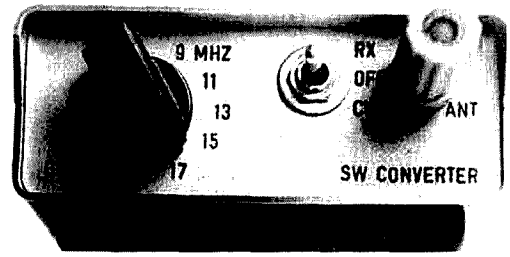
The SWR meter should be connected between your transmitter and the matchbox, after your antenna has been properly adjusted (see below). The purpose of the SWR meter, when connected as just described, is to provide an indication of a proper impedance match *at the transmitter*.

The time to put the SWR meter at the antenna end of the cable is when you are *building* your antenna, or tuning it up the first time you put it in the air. With the SWR meter in place and the transmitter sending low power up the line (just enough that you can get the calibrate function on the SWR meter to work right), work on that antenna. Shorten it, lengthen it, put in tuning stubs, a matching network, or whatever else the antenna handbooks say to do to it, but somehow make that SWR go down. Once you have a *reasonable* SWR, take the meter out of the line and put it down at the station between the matchbox and the rig as an aid to monitoring power output. If the SWR creeps up a bit from one end of the band to the other, don't worry about it — use the matchbox only to keep your rig happy — and enjoy your QSOs.

ham radio

portable shortwave converter

A companion for a receiver described earlier in *ham radio*



Converter front view. The power switch is a two-pole, three-position affair that switches the converter off and leaves the receiver operating as an independent unit. The converter weighs about 12 ounces (340 grams); current drain is 10 mA at 12 Vdc.

To **judge by the amount** of mail pouring in, it appears that the electronic simplicity of my portable monoband receiver project[1] has put it well within the reach of many homebrewers. A frequent inquiry, however, has been how to expand receiver coverage and tune in more bands.

While I've long maintained that a monoband set can be built with considerably fewer spurious responses than multiband affairs, I have to admit that some operators may live with in-band birdies better than I do. With this objective in mind, I conceived a converter designed to go together with the family of receivers of reference 1.

general considerations

The basic principles that determined the receiver design still hold true: the converter must be portable, have a small power drain, and be fully compatible with the GP-58 and 59 receivers described earlier.[1] (The GP-60 is a later version currently operational that was not included in the article at the time the original work was written.)

To make the project easy and compatible with the set, the MHz reading normally occurs on the receiver bandswitch, but when the converter is plugged in, the MHz reading is transferred from the receiver to the converter bandswitch. This keeps the design straightforward and minimizes the number of cables interconnecting the receiver to the converter.

design

Frankly, these sets were not designed with converter operation in mind, so I approached the down-converting scheme with some qualms, even though it proved out better than I'd initially expected. Since

By Jack Perolo, PY2PE1C, P.O. Box 2390, São Paulo, Brasil

the converter can cover (without bandswitching the front end) the range 7-22 MHz, the conversion is made to the receiver's 2.0-3.0 MHz tuning range. Taking as an example the reception of the 11-MHz band (25-meter shortwave broadcast), the overall conversion scheme appears in **fig. 1.**

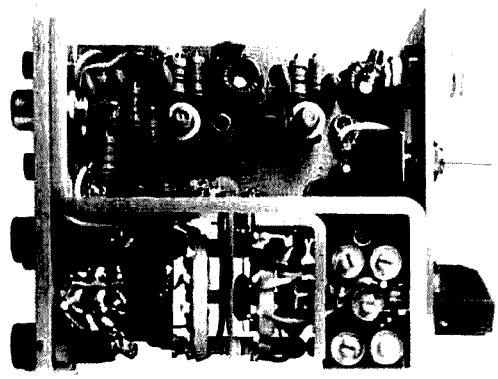
For the sake of experimentation, three different converters were built: the GP-63 is the one described here. It uses HC-25/U crystals and a miniature bandswitch to allow for more compact design. The circuit is not critical if the layout shown in the photos is followed.

construction

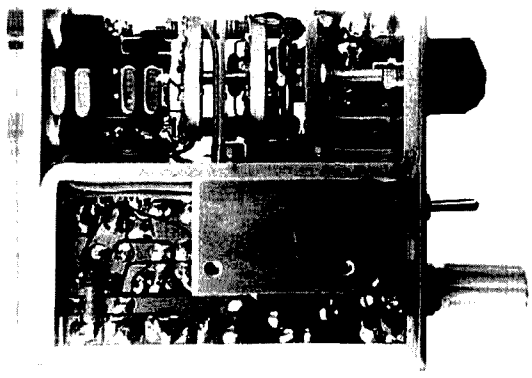
The photos show the GP-63 converter and give details for its duplication. Its schematic is given in **fig. 2.** Cabinet dimensions are 3.5 × 1 × 3.5 inches (90 × 25 × 90 mm). Cabinet material is 16-gauge stainless steel, formed on a 16-ton arbor press. The main chassis and back panel are 1/8-inch (3.2-mm) aluminum. The bandswitch shield is 1/32-inch (1-mm) aluminum. The printed circuit board is mounted on 1/4-inch (6.4-mm) pillars fastened with 4-40 (M3) Allen screws. To avoid rf interaction, the PC board is double sided. The bandswitch is a miniature unit by Centralab with ceramic wafers. All the parts are specified on the schematic and are easily available in the U.S.

power supply

A two-pole, three-position switch on the converter panel controls the 12-Vdc external power supply, allowing for an OFF position for both the receiver *and* the converter, a converter (CV) position when both receiver and converter operate, and a receiver (RX) position, when the converter is switched off and the receiver is used independently. Power consumption is about 10 mA at 12 Vdc, and it is drawn from the same supply of the receiver. To make the converter independent, a 9-volt battery might be used instead, but at the cost of a size increase for the converter cabinet.



Converter top view. The input toroid is on the printed circuit at upper right, followed by the rf transistor, mixer toroid, and mixer transistor to the left. Oscillator transistor is at the lower left-hand corner of the printed circuit. The central aluminum strip acts as converter chassis and shield. Below it at the right are the trimmers, followed by the two-wafer bandswitch, with shielding between them. The adjustment capacitors are at lower left, as are the power input/output jacks.



Converter bottom view. At upper right is the printed circuit supporting the rf trimmers, followed by the bandswitch and, at the left, the crystals (the 13-MHz crystal is missing). Below the central aluminum element is the lower part of the main printed circuit together with its supporting bracket.

conversion to other frequencies

By simple crystal replacement and proper front-end tuning, the converter can be adapted to receive the 14- and 21-MHz Amateur bands (3.5 MHz being received directly by the receiver without requiring external conversion).

An alternative option, perhaps of more interest to Radio Amateurs, could be to increase slightly the receiver coverage (as already mentioned in reference 1) and tune 3-8 MHz. By so doing, both the 80- and 40-meter bands would be covered by the receiver and, by winding fewer turns on the converter coils, would tune 14, 21, and 28 MHz.

Worthy of note is the converter output that is not tuned, its frequency being solely controlled by the input and crystal oscillator; this converter can therefore be easily used at frequencies different from those described here.

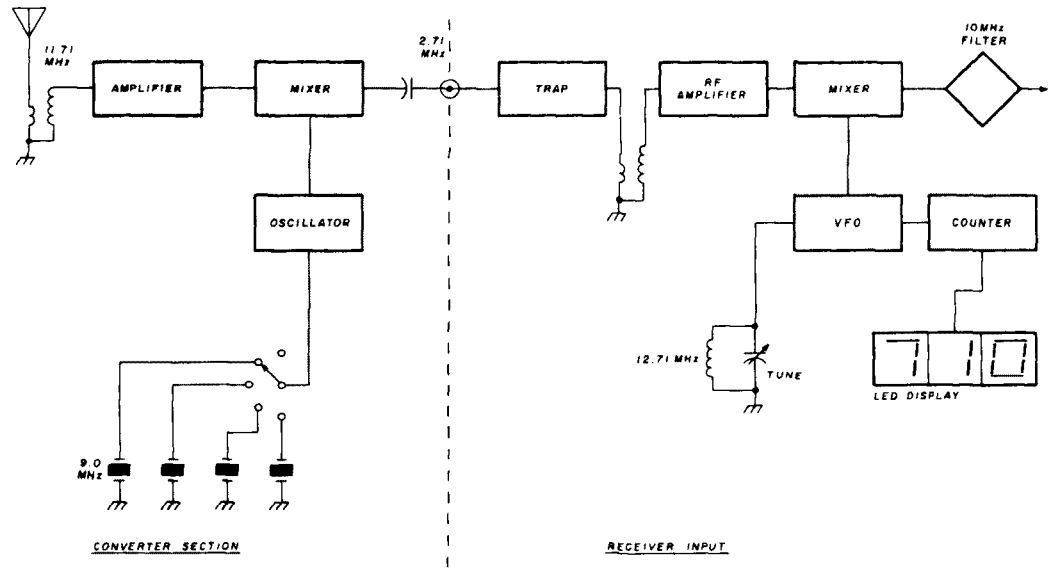


fig. 1. Conversion scheme of the GP-63/GP-60 converter/receiver combination. Set tunes the 2.0-3.0 MHz band and receives on 11.71 MHz.

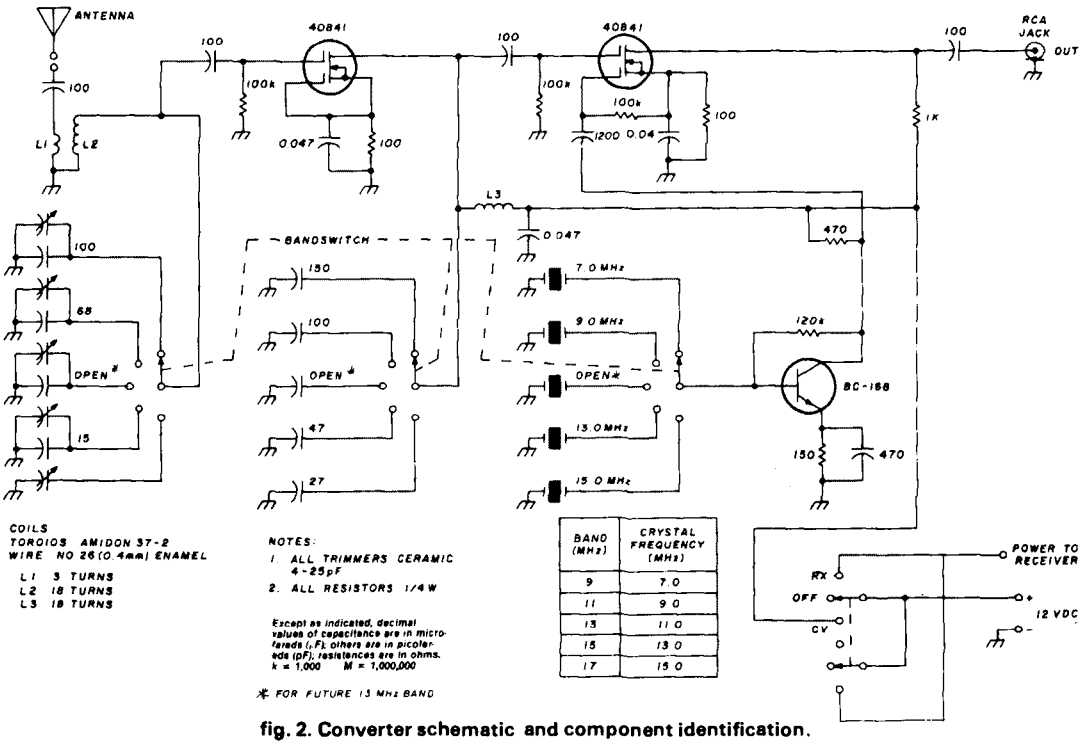


fig. 2. Converter schematic and component identification.

acknowledgment

As always, I'm deeply indebted to Maiso, PY2GP, for his continued counsel and support.

reference

1. J. Perolo, PY2PE1C, "Portable Monoband Shortwave Receiver with Electronic Digital Frequency Readout," *ham radio*, January, 1980, page 42.

ham radio

frequency modulator for a 2-meter synthesizer

Compatible modulation scheme for the CMOS circuit published earlier in *ham radio*

After my 2-meter synthesizer article appeared in *ham radio*[1] I received two letters indicating that my synthesizer, and probably others, cannot be used with certain radios. This is because these sets use a varactor diode in series with the crystal to produce direct fm, and this method will not work with an external oscillator. Many potential builders might be faced with this problem, so I decided to devise a compatible modulation scheme.

predesign

Methods of directly modulating the synthesizer were first considered then rejected, since the circuit boards would have to be modified. Also, I didn't think this approach would work too well anyway. Methods of modulating the synthesizer output were then studied. I breadboarded two quite different cir cuits. One of the two gave the desired performance.

The modulator chosen uses a varactor-tuned tank circuit. Passing a CW signal through such a tank circuit and varying the bias on the varactor results in variable phase shift, or phase modulation. This phase-modulated signal is then converted to fm.

Theory books show that phase and frequency modulation are the same, except that the deviation is independent of modulating frequency with fm and increases linearly with frequency in the case of pm if the modulating amplitude is *kept* constant. Changing pm to fm requires only that the modulating audio be passed through a rolloff filter and is easily achieved with a simple RC filter. The only other design problem is to rid the resulting fm signal of a-m components produced by the modulation process (see below).

modulator design

Fig. 1 is the schematic of the modulator, including an optional speech amplifier.*

*PC boards and many components are available from RADIOKIT, Box 416H, Greenville, N.H. 03048. Circuit boards for the synthesizer are also available.

By Tom Cornell, K9LHA, 3631 North 900E, Greentown, Indiana 46936

The input signal from the synthesizer is attenuated in the resistor divider network (R1, R2, R3) to prevent overdriving the varactor diode, CR1. Audio voltage and approximately 4 volts of bias are fed to the varactor through R7. The modulated output of the tank, L1 and CR1, is fed to three stages of a 7400 quad NAND gate, U1, to eliminate a-m produced by variable attenuation in the tank circuit. The first two stages of the 7400 (U1D, U1C) are biased to increase sensitivity, and the third stage (U1B) provides limiting as well as sufficient drive for the 2-meter transmitter. (You'll note that the same output circuit is used in the synthesizer.[1])

capacitor

C8 across bias resistor R5 rolls off the gain of the 7400 second stage to prevent oscillation during receive mode when drive is removed. This problem did not occur in the breadboard version (which, incidentally, used all four gates of the 7400), and only showed its ugly head after I had made the PC-board artwork and built a board — another proof of Murphy's Law!

To make sure the problem was resolved, I installed a socket in the modified circuit board and plugged in all the 7400s I had on hand. After adding capacitor C8, things calmed down with no drive except when a 74LS00 was used. Steer clear of them in this application!

Dual op-amp U2 comprises a speech amplifier, deviation limiter (clipper), and an output amplifier. Ac gain in both stages is set by heavy negative feedback. The value of R106 can be adjusted to suit a wide variety of microphones, and pot R110 sets the deviation level.

When the speech amplifier is used, R8 and R9 are omitted; these resistors provide bias for the varactor if the speech amplifier is not used. In this case, you may also eliminate the speech amplifier portion of the circuit board if this will help in packaging the modulator. Both 5- and 8-volt supplies may be swiped from the respective regulators in the synthesizer.

alignment

Alignment of the modulator requires only two adjustments. With the modulator connected to the output of the synthesizer, which is set to the center of its frequency range, adjust to produce peak output from the tank circuit. The diode detector probe used in tuning the synthesizer may be of use here. Connect it to one of the outputs of the 7400, and adjust L1 for peak dc voltage out of the probe. If the speech amplifier is used, set R110 for the desired deviation. At this point, you should be ready to use both the synthesizer and modulator with your rig; however, do observe the rig interface information contained in the synthesizer article.[1] Shielding the modulator would be good practice and may, in fact, be necessary.

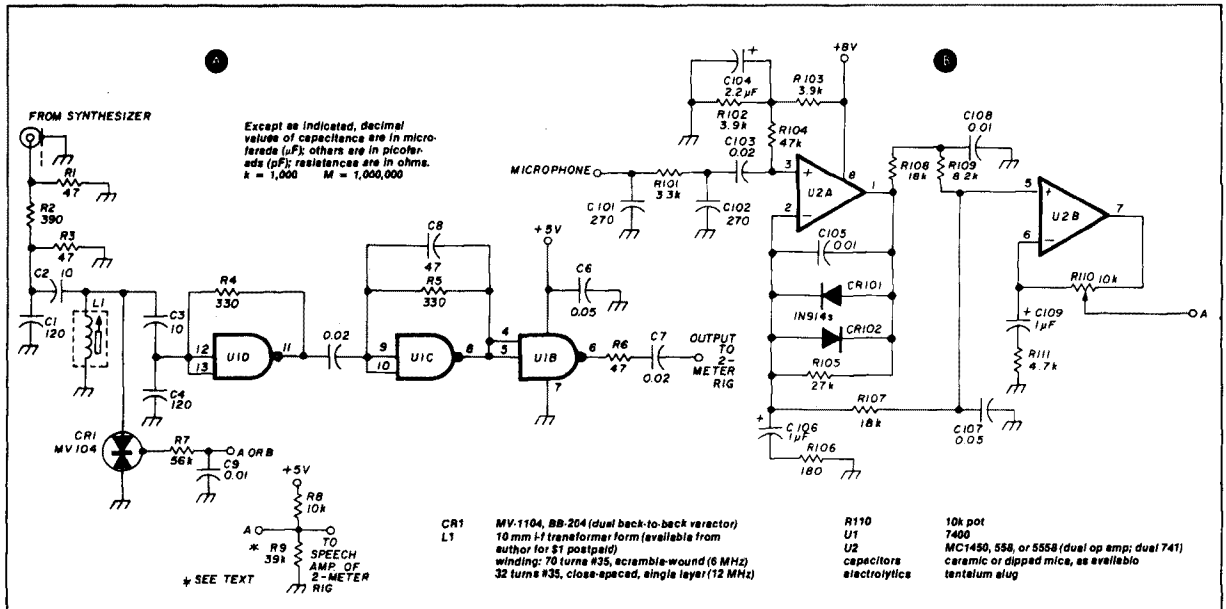


fig. 1. Schematic diagram of the modulator for the synthesizer (A) and an optional speech pre-amplifier, deviation limiter, and output amplifier (B).

transmission-line circuit design for 50 MHz and above

Using distributed resonant circuits for vhf/uhf transmission lines — Part 5: design example for a 2-meter amplifier

This is the fifth and final part of an article on the design of vhf/uhf transmission lines using distributed resonant circuits. A practical design example is presented for a 2-meter amplifier based on general equations and design relationships[1] and basic design data for twelve common line configurations.[2,3,4]

design example

A 2-meter amplifier using 4CX250R tubes is to be constructed, and resonant-circuit transmission-line designs for the plate and grid circuits are required. The amplifier grid and plate circuits are to be contained in a space 17 inches (43.18 cm) wide, 6 inches (15.24 cm) deep, and 8-3/4 inches (22.23 cm) high (standard rack panel height). A 3-inch (7.62 cm) high chassis is available that is 13 inches (33.02 cm) deep and the correct width. The plate circuit enclosure extends 5 inches (12.7 cm) above the chassis. The tubes are mounted at the left end of the chassis, the grid circuit below the chassis, and the plate circuit

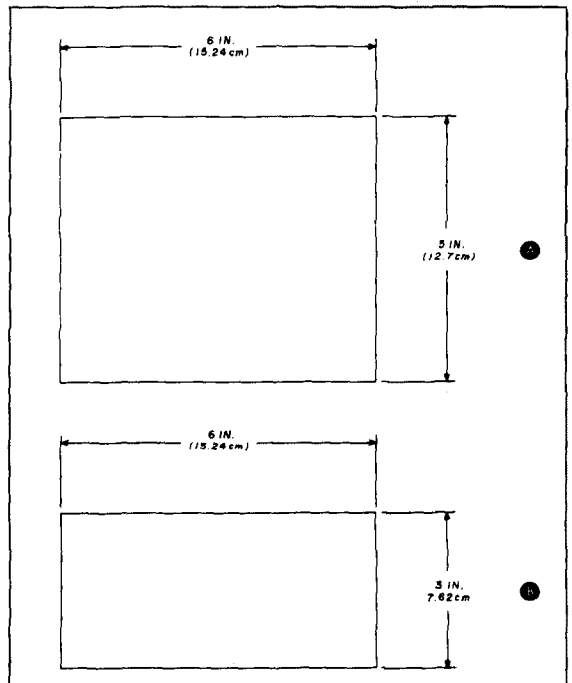


fig. 22. Plate (A) and grid circuit (B) cross-section for 4CX250R resonant circuits discussed in the design example.

By H.M. Meyer, Jr., W6GGV, 29330 Whitley Collins Drive, Rancho Palos Verdes, California 90274

above the chassis. Cross sections for grid and plate circuits are shown in **fig. 22.**

plate-line design

The tubes can be mounted horizontally or vertically. Horizontal mounting (**fig. 23**) permits capacitive coupling of tubes to line, which removes the dc plate voltage from the line. It's necessary to determine if the capacitance that can be obtained by the tube and plate line is adequate.

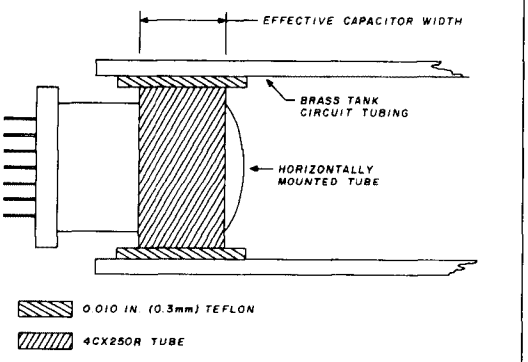


fig. 23. Capacitor formed by tube fin and plate line tube.

table 54. dielectric constant of commonly used insulation materials.

material	dielectric constant (ϵ)*
Gallium Arsenide	12.5
Epsilam-10 (0.025)	10.2 ± 0.5
Epsilam-10 (0.050)	10.6 ± 0.5
96% Aluminia	9.0
Glass (soda-lime)	7.0
Porcelain	6.5
Beryllia	6.5
Fosterite	6.3
Steatite	6.0
G-10 Epoxy Glass Board	4.6
Glass (Borosilicate)	4.6
Epoxy (paper base)	4.2
Phenolic (paper base)	4.0
Boron Nitride	4.0
Mylar	3.0
Nylon	2.9
Teflon Glass PC Board**	2.8-3.8
Teflon	2.4
Polyethylene	2.26
Air	≅ 1.0003
Vacuum	1.0

*100 MHz nominal
**See *Microwave Systems News*, March 1980, page 97, Specing Laminates," R. Webb, for exact details on GT and GX type material.

The width of the 4CX250R plate dissipation fin is 0.71 inch (1.80 cm), which provides a maximum capacitor area of 1.1431 square inches (7.38 square cm).

If 0.010 inch (0.0254 cm) Teflon insulation, which provides a good voltage insulation capability (600 volts/mil), is used between line and amplifier tube, use **eq. 13**[1] to calculate the capacitance. Table **54** lists the dielectric constant values in descending order of ϵ for most commonly used insulation materials. From this table Teflon is 2.4. The capacitance obtained from using **eq. 13** is:

$$C_{pF} = (0.225)(2.4)\left[(1)\ \frac{1.1431}{0.010}\right] = 61.73\ pF \qquad (58)$$

At 144 MHz the equivalent reactance is 15.8 ohms. Considering the power levels involved for a pair of 4CX250R tubes this value is unacceptably high, because the rf current would probably exceed the Teflon dielectric dissipation factor. Consequently, a hard connection to the tubes is required for the plate circuit. Reactance values of 2 ohms or less are acceptable for power levels in the 2-kW PEP range. Also, for this frequency, there's no advantage in mounting the tubes horizontally; thus the simpler vertical mounting directly onto the chassis is to be used.

The minimum center-to-center tube spacing, using the Eimac SK-610 socket, is 2.8 inches (7.11 cm). If a reasonable amount of clearance from line to side wall is to be maintained, a value of 3 inches (7.62 cm) center-to-center is a good choice. From the original 17-inch (43.18-cm) width, 3 inches (7.62 cm) is subtracted, leaving a maximum of 14 inches (35.56 cm) to accommodate the plate line. If allowances are made for connection to the tubes and insulating the line from the chassis, a net maximum length of 13 inches (33.02 cm) remains.

The characteristics for a push-pull tube arrangement are shown in **fig. 24.** C_o is the output capacitance of each tube. The tube capacitances are in series across the plate line. The value of C_o for the 4CX250R is 5 pF maximum. Therefore, the capacitance shunting the line is 2.5 pF.

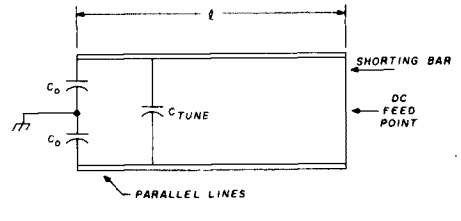


fig. 24. Push-pull configuration for parallel lines in air.

The next step is to calculate the value of Z_0 that results from the available length and the stray and tuning capacitance. The latter is assumed to be 7.5 pF. Using **eqs. 1** through **6** or the HP-67/97 program in **table 1**,[1] Z_0 is calculated as

$$C_{total} = \frac{C_{out}}{2} + C_{tune} \qquad \textbf{(59)}$$

for these conditions:

$$\begin{aligned} F &= 144\,MHz \\ length &= 13.0\,in.\ (33.02\,cm) \\ C_{total} &= 10\,pF \\ C_{tune} &= 7.5\,pF \\ C_{out} &= 5.0\,pF \end{aligned}$$

The following examples use the tables and figures provided. I assume that the programmable calculator will be used.

From **eq. 2** or **fig. 4**,[1] X_c for 10 pF is 110.5 ohms. Using **fig. 5**,[1] β is determined to be about 4.39 degrees/in. (6 degrees/cm) for 144 MHz. Therefore, $\beta\ell = 4.39 \times 13 = 57.2\ degrees$ and the tan $\beta\ell = 1.55$ from **fig. 3**.[1] Rearranging **eq. 1** for Z_0 yields

$$Z_0 = \frac{X_C}{tan\beta\ell} = \frac{112}{1.55} = 72.25\,ohms \qquad \textbf{(60)}$$

This is a low value of Z_0 for parallel lines, indicating that the line length should be shorter to yield values of Z_0 between 150 and 400 ohms. If 150 ohms is chosen and X_C remains the same (112 ohms), tan $\beta\ell = \frac{112}{150} = 0.75$ and $\beta\ell$ is 36.87 electrical degrees long. Dividing by $\beta = 4.39\ degrees/inch$ gives $\ell = 8.4\ inches$ (21.33 cm). This says the 17-inch (43.18-cm) wide enclosure is very generous, and 13 inches (33.02 cm) would be adequate.

The physical dimensions of the line can be determined from **fig. 17**.[1] From the geometry of **fig. 23** and placing the line in the center of the cross section, $h = 2.5\ inches$ (6.4 cm) over the chassis ground plane. If copper water pipe with an outside diameter of 0.625 inch (1.59 cm) is used for the lines, $\frac{h}{d} = \frac{2.5}{0.625} = 4$. Entering the graph of **fig. 17** for a value of $\frac{h}{d} = 4$ and moving up to the $Z_0 = 150\text{-}ohm$ line yields a $\frac{D}{h}$ value of 0.6. Therefore, D, the center-to-center spacing of the lines, is 0.6×2.5 or 1.5 inches (3.8 cm), an acceptable value. If other spacing is desired, other line diameters can be tried.

The disc tuning capacitor is calculated using **fig. 6**.[1] A variable capacitor of sufficient insulation can also be used; the choice is left to the reader.

Often the line is made intentionally longer and a shorting bar used to set the final operating point. That choice is not necessary if the data provided here are used.

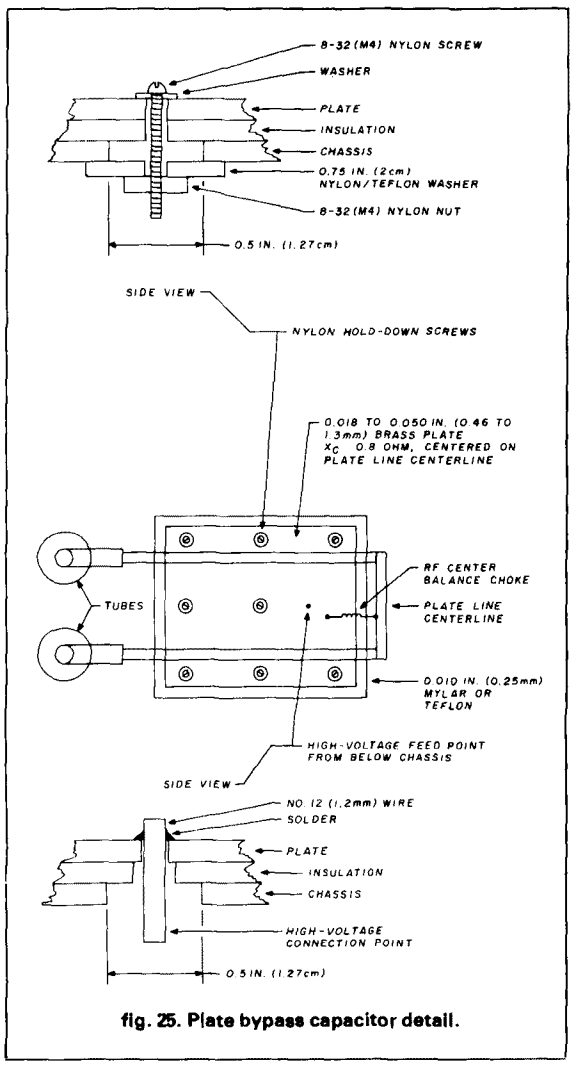


fig. 25. Plate bypass capacitor detail.

In **fig. 25**, the dc feed point is indicated. It is impossible to predict the exact rf balance point because of stray reactances. So, it is good design practice to insert a small rf choke at this point. Four turns of no. 12 wire, 3/8 inch (0.95 cm) in diameter and 0.5 inch (1.27 cm) long, are adequate. This permits the rf balance point to center itself at some point in the rf choke. The dimensions of this rf choke are not critical, but it should have a reasonably high Q. The highest rf choke Q is generally obtained when the wires are spaced a wire diameter apart — the pitch is equal to twice the wire diameter. Callendar's equation (reference 5) is readily used with this pitch to estimate coil Q:

$$Q = \frac{\sqrt{F}}{\frac{2.71}{a} + \frac{2.13}{\ell}} \quad (61)$$

where F = frequency (Hertz)
a = choke radius to center of turn (inches)
ℓ = choke length to center of first-to-last turn (inches)

This equation is accurate to within a few per cent and, for close-wound rf chokes, is high by a factor of almost two.

Reference 6 contains a comprehensive discussion of inductances, Q, and the calculation of single-layer solenoid choke parameters.

A further important consideration is the plate circuit rf bypass capacitor and its placement providing balanced, low-inductance rf current return paths to the tube cathodes. One of the better choices for a capacitor is a parallel plate type that uses the chassis as one of the capacitor plates and is centered under the line between the tubes and the line-support mechanism at the shorted end. The plate is secured to the chassis with insulating washers and nylon screws. Fig. 25 shows a typical installation, with details for the high-voltage feedthrough insulation hold-downs. The capacitor reactance should be less than 1.5 ohms. At 144 MHz, a 5-inch (12.7 cm) by 7-inch (17.78 cm) plate, using 0.010 inch (0.25 mm) Teflon insulation, provides an 1890 pF capacitor with a reactance of 0.58 ohm. Note that the capacitor is placed so that the high plate rf currents find equal and balanced paths to the tube cathode. Using this technique, the high voltage feed point is cold to rf below the chassis. Make sure that the small balance inductor is soldered to a centerline point on top of the capacitor. Balanced rf currents produce stable amplification.

If a fixed rf bypass capacitor of appropriate quality is used, the same current balance considerations apply. The balancing rf choke is also required. This completes the plate line design. Refinements to final values can be readily made as desired.

grid-line design

The grid-line design proceeds in a manner similar to that of the plate-line design. However, the critical difference for most tubes is that input capacitance is quite high. The 4CX250R input capacity is 17.2 pF maximum for grounded cathode configurations. For the design configuration considered here, fig. 24 applies. The net capacitance across the lines is 8.6 pF. Note that the push-pull configuration reduces the tube input capacitance by two over single-ended designs, a possibly important tradeoff for higher frequencies. If a dual 20 pF tuning capacitor is available, and it is assumed to be set at the 15-pF per section point, the net tuning capacitor is 7.5 pF in parallel with the tube capacitance of 8.6 pF for a total of 16.1 pF. At 144 MHz, from fig. 4,[1] this is about 50 ohms. Going back to eq. 11 and rearranging, $\tan \beta \ell = \frac{X_c}{Z_0}$. And assuming a Z_0 of 150 ohms, $\tan \beta \ell = \frac{50}{150} = 0.33$. Referring to fig. 3, the $\beta \ell$ length is 21.25 degrees, or 4.84 inches (12.29 cm), if β is 4.39 degrees/inch.

From the geometry described in fig. 22, $h = 1.5$ inches (3.81 cm), requiring the line to be centered in the chassis. If no. 10 wire (0.102 inch, 0.26 cm) is used for the line, $\frac{h}{d} = \frac{1.5}{0.102} = 14.71$. Referring to fig. 17 and entering at a value of 14.71 for h/d provides a value of 0.13 for D/h. Solving for D, the center-to-center distance of the grid lines gives $D = 0.13h = 0.13 \times 1.5 = 0.2$ inch (0.51 cm). This is not a practical value, because the outside diameter spacing of the conductor leaves only 0.098 inch (0.25 cm) separation. If a Z_0 of 350 ohms is chosen, the length will change but the D will increase, from fig. 17, to $1.5 \times 0.7 = 1.1$ inches (2.67 cm), an acceptable value. The new line length is now calculated for $Z_0 = 350$ ohms, $\tan \beta \ell = \frac{50}{350} = 0.143$. Referring to fig. 3, this is about 10 degrees. Dividing by 4.39 (β degrees/inch) yields 2.28 inches (5.8 cm) line length.

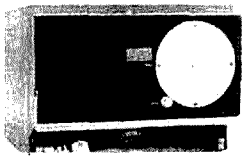
It is clear that this design is now realizable. But electrical line lengths of 12 degrees or less are undesirable; the minimum value should be about 20 degrees. Remember the tuning capacitor we chose earlier and its setting of 7.5 pF net capacitance across the line? If that is reduced to 5 pF, the line length can be extended to an acceptable value.

As in the plate line, a balancing rf choke is used at the center point of the bias feed for the grids. Five turns of no. 16 wire, 0.25 inch (0.65 cm) in diameter and 0.5 inch (1.27 cm) long, are adequate. The same rules stated earlier for balancing rf currents apply here. The grid rf bypass capacitor is grounded on the centerline of the tubes and grid line. A parallel plate is not recommended for the grid because, in this case, it would interfere with the plate circuit bypass capacitor.

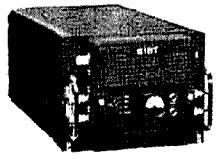
special consideration

If the 4CX250R tubes described here for 144 MHz use were considered for 432 MHz single-ended use, the input capacitance of 17.2 pF maximum places the first $\frac{\lambda}{4}$ point inside the tube header, even if the line Z_0 is chosen to be 10 ohms — a relatively impractical number. Because of the required line diameter and close spacing to the ground plane a coaxial tank is assumed. A simple solution is to use multiple $\frac{\lambda}{4}$ line

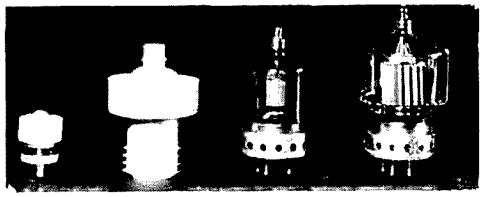
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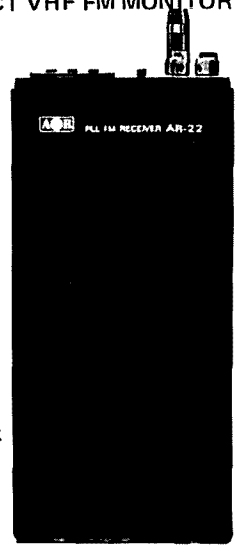
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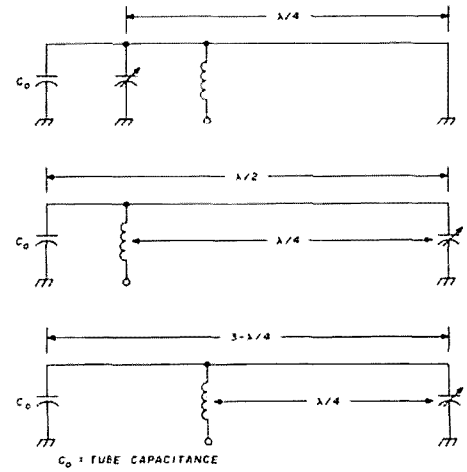


fig. 26. Line feed configuration for multiple λ/4 segments.

lengths as shown in **fig. 26.**

comments

The example presented is simple, but it does show the required iterative design process you can implement to achieve a specific solution. Much has been left unsaid. The shortened line at uhf and above due to device capacitance deserves an equally lengthy treatment, as does the microstrip design area, which was not discussed here at all.

acknowledgments

Comments by S. Harrison, WB6PKA, Dr. R.M. Searing, and T.C. McDermott, III, N5EG, are gratefully acknowledged. The most valuable contributions were provided by B.L. Reardon, to whom the author is singularly indebted.

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ham radio

improved receiver performance for the Heathkit SB-104A

Modifications for better sensitivity, selectivity, and overload capability

The **Heath SB-104A** is a **good transceiver**. It can be made even better by incorporating the simple modifications described in this article. The modifications, if made according to the directions given, will provide significant improvements in:

1. Receiver sensitivity, especially on the 10- and 15-meter bands;
2. Receiver selectivity in the SSB mode;
3. Receiver strong-signal-handling capability.

These modifications, as well as a few others, have been developed over a two-year period with great care and attention to detail. Before snipping any wires, I strongly recommend that you fully understand what is being accomplished by each and every circuit change. In addition, the modified circuits should be studied and compared with the original Heath circuits.

receiver sensitivity improvements

In my opinion, the SB-104A suffers from inadequate sensitivity, especially on 10 and 15 meters. The six bandpass filters for the 80- through 10-meter Amateur bands, located on circuit board **G**, are diode switched. That is, when the radio is on a particular band, diodes on circuit-board **G** associated with the bandpass filter in use are forward-biased to provide a low-loss rf path for that band. The diodes do have some loss, however. These losses can be reduced by replacing diodes D701 through D704 (Heathkit parts designations); D707 through D710; D713, D714; and D717, D718 with Motorola MPN3401 PIN diodes,* which are intended for rf-switching use. (See **fig. 1**.)

To make the mods, first remove the original diodes, using a Solderwick.™ Install the new PIN devices in place of the original diodes. Pay attention to the polarity of the MPN3401s. These devices are in a square epoxy package; the end with the ridge, or high spot, is the cathode. The leads on the MPN3401 are very short, so they must be mounted on the foil side of the board.

mixer improvements

The next step is to replace the receiver mixers. The original first and second mixers on board **G** can be improved by substituting minicircuit Labs SBL-1 broadband mixers.†

These new mixers provide better isolation between ports and have less conversion loss than the original mixers. They also have good strong-signal-handling capabilities. They are commonly used in high-performance uhf receiving systems.

To make the mixer modification, first remove the Heath first mixer, consisting of T701 and T702 and diodes D719, D721, D722, and D723. Also remove capacitors C741 and C742. Apply some epoxy to the top of one of the SBL-1 mixers and cement it to the component side of the board, as indicated in **fig. 1**. The pins on the mixer should now be facing upward. Wire the mixer as shown using two 0.01-μF capaci-

*Available from Circuit Specialists, Box 3047, Scottsdale, Arizona 85257.

†Available from Advanced Receiver Research, Box 1242, Burlington, Connecticut 06013.

By Richard Tashner, N2EO, 163-34 21 Road, Whitestone, New York 11357

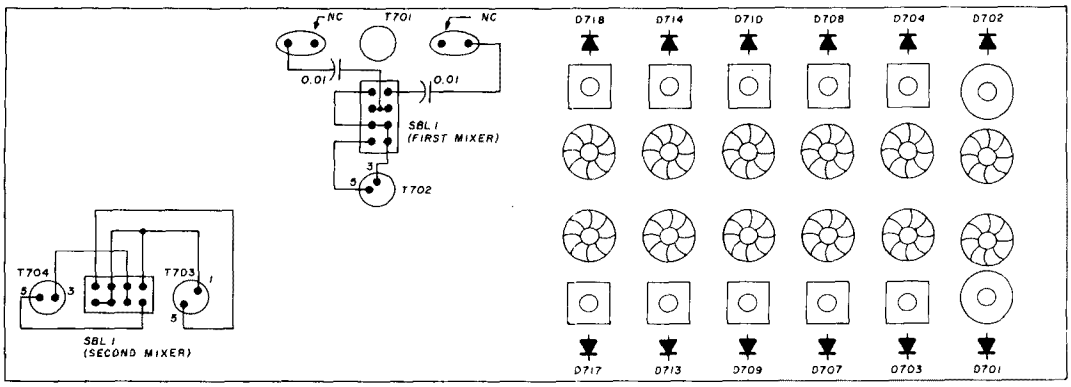


fig. 1. Circuit board *G* in the Heath SB-104A showing, at right, the locations of the original bandpass-filter switching diodes, which are replaced with MPN3401 PIN diodes to reduce loss through the circuit. The original first and second mixers on board *G* (center and left) are replaced with SBL-1 broadband mixers to reduce conversion loss and improve strong-signal-handling capability. Original Heath parts designators are shown.

tors. The capacitors connect from the mixer module to one of each of the indicated holes in the PC board.

Next remove the Heath second mixer by removing T703, T704, D724, D725, D726, D727, and epoxy the new SBL-1 second mixer to the board. Wire as indicated. No additional capacitors are needed on the second mixer, as they already exist on the PC board.

Finally locate transistor Q702. This transistor is a 2N5109, which is an epitaxial planar low-noise device. It is used as a post amplifier between the first and second mixers.

Remove R721, the 1-kilohm collector resistor and replace it with a 1-mH choke. Next remove R722, the 560-ohm emitter resistor, and replace it with a 100-ohm resistor. Finally replace C745 emitter bypass capacitor with a 0.01-μF disc capacitor.

The above modification serves two purposes. First, it increases collector current to about 100 mA, which greatly reduces the chances for the stage to clip on strong signals. (The 2N5109 is rated for an IC of 400 mA.) It also increases the stage gain, which is needed to overcome the losses of the second crystal filter.

At this point, reinstall board **G**. Turn on the SB-104A, and check out the receiver to make sure it's receiving on all bands.

Next pull out the board, install the extender board in the SB-104A along with board **G**, and retune the filters and second mixer trimmers according to the Heath operation manual. If a scope and sweep generator are available, the board may be sweep-aligned.

taming the noise blanker

The next step is to rewire the noise blanker as shown in **fig. 2**. This modification will allow the blanker to be totally removed from the signal path when turned off. I found that the blanker caused cross modulation, even when turned off, by virtue of its being in the signal path at all times as originally wired. The noise-blanker switch is a dpdt and no problems should be encountered in wiring it as indicated in **fig. 2**. Use shielded cable (RG-174/U).

improving SSB selectivity

To improve skirt selectivity on SSB, remove the original crystal filter from circuit board **E** and install a Fox Tango Corporation 33H2.1 filter* in its place. Mount the original SSB filter to the chassis just to the left of the VFO, directly in front of the noise blanker. I suggest that you measure the filter dimensions carefully; make a template, and tape it to the chassis before drilling the four mounting holes. Drill up from the bottom of the chassis.

The new filter is wired as shown in **fig. 2**, using two 15.5-μH coils and two 150-pF mica capacitors, which provide the proper impedance match for the filter.

further improvements

More modifications were made to the SB-104A to achieve the following goals:

*Available from Fox Tango Corporation, Box 15944, West Palm Beach, Florida 33406.

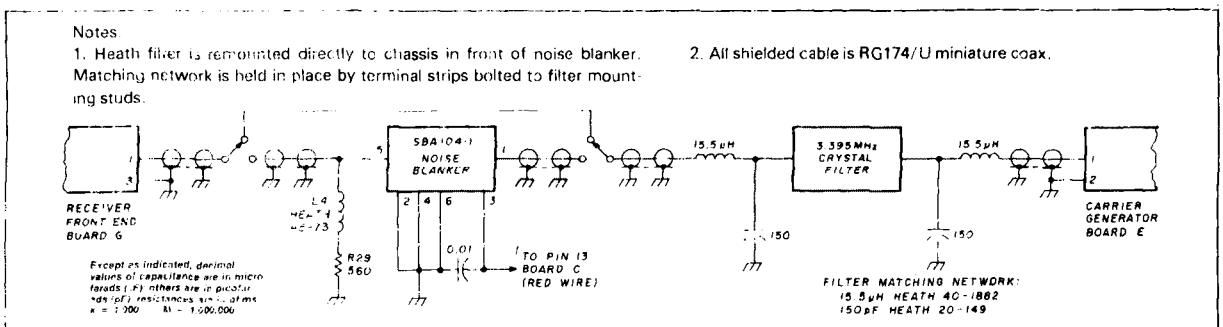


fig. 2. Block diagram showing cascaded filter system. A Fox Tango Corporation 33H2.1 filter is substituted for the original Heath crystal filter, which is relocated on the chassis as described in the text. Wiring changes to the noise blanker are also shown, completely removing it from the signal path when turned off.

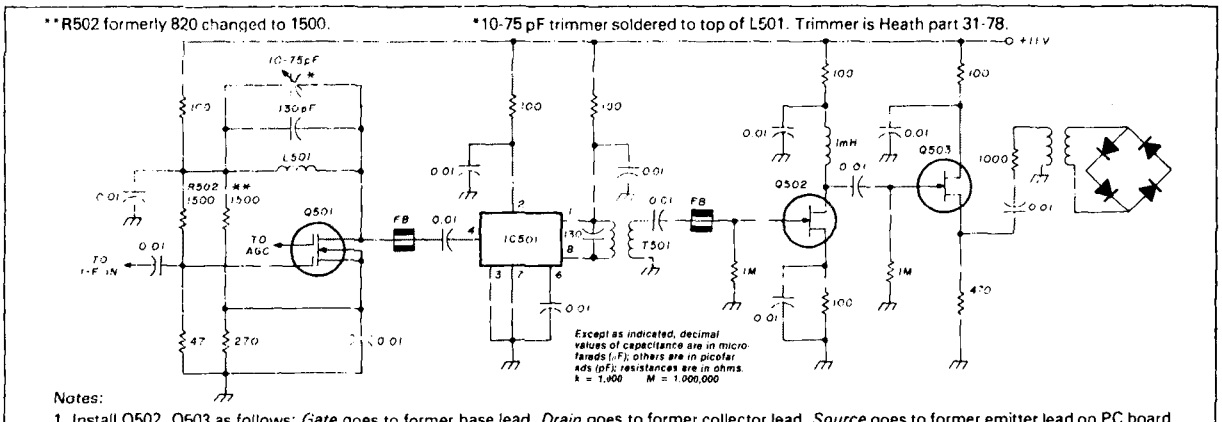
1. To further improve strong-signal-handling capability
2. To improve the active audio filter
3. To reduce receiver hiss
4. To provide a slower AGC release time

Make the following changes to board **F**. Refer to **fig. 3**, which is a partial schematic of board **F**. (Parts designators are as shown in the Heath schematic.*) Proceed as follows:

1. **R513**. Remove the 2400-ohm resistor and replace it with a 1-meg resistor.
2. **R502**. Remove the 820-ohm resistor and replace it with a 1500-ohm resistor.

*As mentioned at the beginning of this article, it is important that you understand just what is being done when these modifications are made. *Before* attempting to make any changes, study the Heath schematics for the SB-104A and familiarize yourself with the original design so that you *thoroughly understand* how the changes are made, why they are made, what components are involved, and how to proceed without damaging the radio. The importance of this advice cannot be overly stressed.

3. **R514**. Remove the 620-ohm resistor and replace it with a 100-ohm resistor shunted by a 0.01-µF capacitor.
4. **R517**. Remove the 2400-ohm resistor and short the foil with a jumper.
5. **R511**. Remove and discard (or save for your junkbox).
6. **R512**. Remove the 4700-ohm resistor and replace it with a 1-mH choke.
7. **R516**. Remove and discard.
8. **R518**. Remove the 10k resistor and replace it with a 1-meg resistor.
9. **R572**. Remove the 4700-ohm resistor and replace it with a 2200-ohm resistor.
10. **R541**. Remove the 1500-ohm resistor and replace it with a 1000-ohm resistor.



Notes:
1. Install Q502, Q503 as follows: *Gate* goes to former base lead. *Drain* goes to former collector lead. *Source* goes to former emitter lead on PC board.

fig. 3. Partial schematic of the SB-104A i-f/audio board *F* showing modifications to improve strong-signal-handling capability.

11. R545. Remove the 820k resistor and replace it with a 2.2-meg resistor.

12. R546. Remove the 5.6-meg resistor and replace it with a 33-meg resistor.

13. C535. Remove the 2.2-μF tantalum capacitor and replace it with a 5-μF, 15-volt electrolytic capacitor.

14. Q502, Q503. Remove and replace with 2N3819 JFETs. See note 1 on **fig. 3**.

On the right-hand upper corner of board **F**, from the component side of the board, locate the foil going to Q517 base and carefully drill a 1/16-inch (1.6-mm) or smaller hole through the base foil and the ground foil. Scrape off the green or blue coating around the holes and install a 0.1-μF Mylar capacitor in the two holes.

Locate coil L501 and remove the associated 100-pF mica capacitor. Replace it with a 130-pF mica capacitor.

Solder a 10-75 pF trimmer (Heathkit 31-78) across the pins of L501. Piggyback this trimmer on top of L501 by soldering the trimmer directly to the top of the pins on L501.

Install board **F** in the extender board in the SB-104A. Either peak the 10-75 pF trimmer for maximum noise, or, if a signal generator is available, put the rig on 80 meters and inject a signal into the antenna jack. Use only enough signal to get an S-5 or so meter reading. Peak the 10-75 pF trimmer for maximum S-5 meter reading. Use care not to saturate the i-f. Use only as high a signal level as is necessary.

Next, remove board **D** and change capacitor C441 (33 pF) to 100 pF. This change increases HFO injection and reduces receiver overload. Reinstall board **D**.

Remove transmit audio regulator board **B**, and make the following changes:

1. Change R217 from 4700 to 2200 ohms.

2. Remove Q207 and replace it with a Radio Shack 276-2026 transistor.

The reason for these changes on board **B** is as follows. Q207 is the PTT switching transistor. When Q207 conducts, the relay in the SB-104A closes, and the unit is in the transmit mode. Before I changed the transistor, I'd had two failures of the Q207. For that reason, the Radio Shack device was installed; it's a tab-type transistor and is more capable of supplying the necessary collector current without premature failure.

If this change is made, you must reduce the value of R217 from 4700 ohms to 2200 ohms. If you don't plan to change Q207, leave R217 alone. When installing the new Q207, bend the leads of the transistor at a right angle and allow the transistor to lie over the top of IC202. This will allow PC board **B** to slip into its compartment in the chassis.

Additional changes to board **B**, which are optional, are as follows. R214, the collector resistor of audio transistor Q201, may be reduced from 33k to 15k. This change will eliminate asymmetrical clipping — which may cause slight audio distortion during transmit in some units — in Q201.

Capacitor C204, the 0.01-μF coupling capacitor on Q201's base, may be increased to a 0.1-μF Mylar. This change will increase the low-frequency response of the transmit audio. This is a personal preference. You may like the transmitter audio better one way than the other, so get some on-the-air checks from a few local stations and try the two different capacitor values.

Finally, one change suggested by Heathkit is as follows. Remove the ALC/filter board and change capacitor C887 on Q802's emitter to a 0.68-μF tantalum. If your rig is of late vintage, the 0.68-μF cap may already be installed.

test results after modification

Three other active Amateurs are located within a half mile of me. After modifications were made, I made on-the-air checks with two of these stations. I was able to tune my SB-104A 18-20 kHz away from the other stations' 60 dB over S-9 signals and only slight desensitization was noted. Stations as weak as S-3, 30 kHz away from the 60-dB over S-9 local SSB signals, were solid copy, and only a slight hiss was noted while the local station was transmitting. These tests were made with the noise blanker off.

The Heathkit SB-104A was also tested side-by-side with a top-of-the line Japanese transceiver. Both rigs were connected to a common antenna. The two units ran neck-and-neck as far as sensitivity was concerned. All bands, 80-10 meters, were tested. When the two rigs were tuned to the same station, the SB-104A had much less receiver hiss than the Japanese rig, which made the SB-104A much more pleasant to listen to. The modified AGC action was very pleasant to listen to. No pumping was present in the SB-104A after modification.

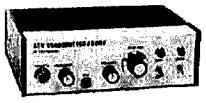
A comparative check of selectivity was also made on both units. Tuning the same station on upper sideband on the Japanese rig, and moving off frequency produced a high-pitched "Donald Duck" response that could be heard up to 3.5 kHz away from center frequency. However, on the SB-104A, tuning more than 2.8 kHz away from the center fre-

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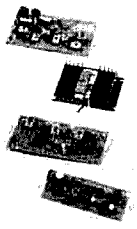
- You can send broadcast quality video of home movies, video tapes, computer games, atc, at a cost that is less than sloscan.
- Really improves public service communications for parades, RACES, CAP searches, weather watch, etc.
- DX is about the same as 2 meter simplex – 15 to 100 miles.

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quency produced a sharp cutoff of the signal, and the same signal that was heard 3.5 kHz away on the Japanese rig was undetectable on the SB-104A. The i-f shift control in the Japanese rig was purposely left in the center position and not used during the checks. Turning the i-f shift knob did not help the Japanese rig; however, the cascaded filters in the SB-104A were definitely doing their job. Before modification, the SB-104A exhibited lockup of the AGC, which would manifest itself with the S-meter hanging up at S-6 across large portions of the band when a strong local signal was on. After modification, this problem totally disappeared, and just a barely perceptible increase in hiss was noted.

some afterthoughts concerning the SB-104A

As mentioned, the tests were made with the SB-104A noise blanker turned off. Turning on the blanker still produces cross modulation. This is because the noise blanker keys on signal as well as noise. Because of the broadband nature of the rig, the blanker is subjected to 500 kHz or more of crowded spectrum when turned on, and it just can't handle that much signal. One answer to this problem is to put a monolithic crystal filter about 6 or 8 kHz wide ahead of the noise blanker. During the modifications, I placed the 2.1-kHz filter ahead of the noise blanker, and the cross modulation totally disappeared. However, the blanker became totally ineffective on noise spikes. Propagation through the filter caused the pulses to be rounded off, rendering the blanker ineffective. For this reason only a modest filter should be placed in front of the blanker so that the pulses will not be rounded off, and the spread range of signals presented to the blanker at any one time will be reduced.

I would greatly appreciate hearing from others who have done work in this area, and I will answer questions upon receipt of a self-addressed stamped envelope.

acknowledgments

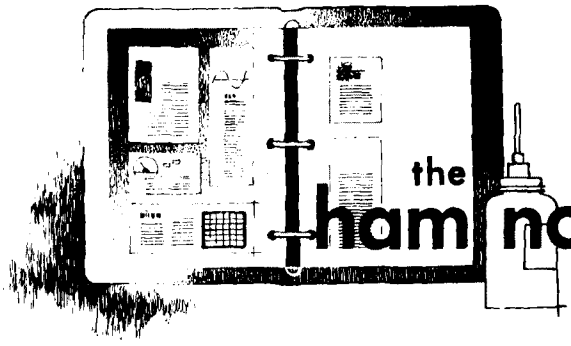
I with to thank Vinney Maida, WA2EVS, for his helpful suggestions with this project. Thanks also to Brian Selman for drafting the diagrams. Finally, my thanks to David Fentem, WB4RRC, for his ideas in his "Heath 104 Series Information Sheet," dated August 31, 1979.

bibliography

Shuch, Paul, WA6UAM, "Circuit Packaging for UHF Double-Balanced Mixers," *ham radio*, September, 1977, page 41.

The Radio Amateurs Handbook, Chapter 8, "Receiving Systems," Chapter 9, and "VHF and UHF Receiving Techniques," ARRL, Newington, Connecticut, 1979.

ham radio



measuring receiver dynamic range: an addendum

In a previous article[1] I explored methods for determining performance of manufactured receivers using simple equipment and procedures. I'd like to update these data with the results of some further measurements (table 1).

table 1. Updated measurements of manufactured receiver performance in terms of local-oscillator phase noise. Data supplements those in reference 1.

receiver	two tone input (dBm)	blocking (dBm)	bandwidth (kHz) at a rejection of 60 dB	70 dB	80 dB	90 dB	S-meter (S9 level, μV, and linearity)
Collins KWM 380	−33	−40[4]	10.0[6]	15.6[6]	—[6]	—[6]	71 excellent
Drake TR7/DR7 No. 2 late	−34	−42[4]	3.9	4.3	4.6	4.8	63 good
Ten-Tec Omni-D No. 2	−38	−21	4.1	4.7	5.9	9.5	63 good
Drake TR7/DR7 No. 3 late	−39	−44[4]	4.3	4.9	5.6	—[6]	20 good
Drake TR7/DR7 No. 1 early	−41	−32	3.8	5.6	6.3	6.6	22 fair
Ten-Tec Omni-D, *B series*	−42	−21	4.0	5.0	6.5	11.4	71 good
Collins 7553B late	−44	−20	4.5	5.1	5.8	6.3	250 good
ICOM IC-701 No. 1	−46	−26	5.2	9.4	15.4	—	20 poor
Swan Astro 102 BX	−46	−36	4.2	7.5	15.2	—	71 fair
Yaesu FT-107M	−46	−38	3.6	3.8	4.0	24	2 bad
Ten-Tec Omni-D No. 1	−48	−20	4.4	6.3	10.1	—	36 good
Ten-Tec 544 (Triton IV)	−48	−30	6.0	—	—	—	20 poor
ICOM IC-701 No. 2	−49	−45	7.4	—	—	—	35 fair
Swan Astro 150	−50	−30	4.4	5.1	12	—	89 fair
Atlas 350XL	−51	−28		4.0		7.0	150 poor
Collins 7553B early	−51	−32					
CIR Astro 200	−52	−35					
Yaesu FT-101ZD No. 1	−53	−43	3.4	3.8	5.3	6.5	25 fair
Ten-Tec Century 21	−54	−20					
Yaesu FT-901DM	−56	−29	3.6	7.6	16.7	—	8 poor
Drake R4C	−57	−34[5]	4.0	4.5	4.6	4.6	16 good
Yaesu FT-101ZD No. 2	−57	−41	3.8	4.0	4.1	5.0	22 good
Ten-Tec Argonaut[1]	−58	−35	4.0	5.5	14	18	8 poor
Kenwood TS-820S	−60	−34					110 good
Kenwood R-820	−60	−42[4]	3.8	5.2	12	—	50 excellent
Kenwood TS-120S No. 1	−62	−40	4.1	8.0	—	—	50 fair
Yaesu FT-301S	−64	−36					30 poor
Heathkit SB-303[2]	−64	−41	4.4	6.0	9.0	10	70 good
Collins KWM2 No. 2	−65	−26	4.5	5.1	6.0	6.3	20 poor
Yaesu FT-101E	−65	−36					10 good
Signal One CX7A[3]	−66	> −6	3.2	6.3	7.1	7.1	20 excellent
Yaesu FT-301D	−68	−32					65 poor
Kenwood TS-520S	−72	−36					70 fair
Collins KWM2 No. 1	−74	−33					
Kenwood TS-120S No. 2 and No. 3	appx. −100	appx. −50					
OTHER EQUIPMENT							
Drake R7 preamp off	−31	−43[4]	4.2	5.0	6.0	—	50 excellent
preamp on	−42	−48[4]					
Kenwood TS-180S	−66	−50	4.2	4.3	4.5	4.8	80 good
	−71	−51	4.4	6.8	24	—	

Notes:
1 Modified for maximum selectivity.
2 Modified mixers.
3 Modified for maximum sensitivity.
4 LO phase noise is causing these low readings, also causes two-tone inputs to look better than they really are.
5 For a close-in signal, 4 kHz spacing.
6 Selectivity is being compromised by LO phase noise.

As you can see by examining table 1, the next area deserving attention is reduced local-oscillator phase noise. Several of the better radios could be much improved in the reciprocal mixing area, thus better use could be made of their excellent filters if the phase-locked loop bandwidth were reduced.

Another problem cropping up is the presense of *many* strong spurious responses when receiving a single strong signal, as in the selectivity test.[1] Almost every radio using a synthesized local oscillator has this problem. Equipment using a more conventional scheme is usually clean or has only an occasional spur.

Let's keep up the pressure on receiver manufacturers to do a better job in these areas.

reference

1. Sidney Kaiser, WB6CTW, "Measuring Receiver Dynamic Range," *ham radio*, November, 1979, page 56.

Sid Kaiser, WB6CTW

geostationary satellite bearings with the TI-58/59 programmable calculator

This TI-58/59 program will give the elevation and azimuth antenna bearings needed to acquire geostationary satellites for any location on earth.

WB8DQT[1] gave an excellent description of the seven-step equation used, so I will give only the details needed for use with the TI-58/59 calculator.

The program takes from 4 to 9 seconds to run after E′ is pressed. Initial memory partitioning is adequate. Angular mode is degrees. Elevation and azimuth are displayed to the nearest tenth of a degree, close enough for any ham application. An elevation of 90 degrees is straight up so no azimuth is needed.

reference

1. Ralph E. Taggart, WB8DQT, "Microcomputers and Your Satellite Station," *73*, February, 1980.

Larry Kushner, WA6BKC

TITLE GEOSTATIONARY SATELLITE BEARINGS PAGE 1 OF 1 — TI Programmable **Program Record**

PROGRAMMER LARRY KUSHNER DATE JUNE 10, 1980

Partitioning (Op 17) 4, 7, 9, 5, 9 Library Module NONE Printer NO Cards 1

PROGRAM DESCRIPTION

THIS PROGRAM WILL CALCULATE THE ELEVATION & AZIMUTH ANTENNA BEARINGS NEEDED TO SEE GEOSTATIONARY SATELLITES. GIVEN: THE STATION LOCATION IN DDD.MMSS FORMAT AND THE SATELLITE SUBPOINT LONGITUDE IN DDD.d FORMAT, THE ELEVATION AND AZIMUTH WILL BE IN DDD.d FORMAT. IF THE ELEVATION IS A (-) NUMBER THE SATELLITE CAN NOT BE SEEN FROM YOUR LOCATION. THE EQUATION USED IS FROM FEB. 1980 73 MAGAZINE BY WB8DQT.

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	READ MAG CARD SIDE 1			
2	ENTER STATION LATITUDE	26	A	26
3	ENTER STATION LONGITUDE	80.1	B	80.1
4	ENTER SATELLITE SUBPOINT LONGITUDE	135	C	135
5	RUN PROGRAM (ELEVATION WILL BE DISPLAYED)		E′	59.1
6	TO FIND AZIMUTH		E	168.3
7	TO FIND ELEVATION		D	59.1
8	ENTER NEXT SATELLITE SUBPOINT LONGITUDE	128	C	128
9	RUN PROGRAM (ELEVATION WILL BE DISPLAYED)		E′	29.5
	GO TO STEPS 2,3,4,5,6,7 AS NEEDED			
	FOR ALL NUMBERS ENTERED: + FOR °N, °W. - FOR °S, °E.			

USER DEFINED KEYS	DATA REGISTERS	LABELS (Op 08)
A STATION LATITUDE	0	
B STATION LONGITUDE	1	
C SATELLITE LONGITUDE	2	
D ELEVATION	3 L	
E AZIMUTH	4 D	
A	5 C THEN AZIMUTH	
B	6 ELEVATION	
C	7 SATELLITE LONGITUDE	
D	8 STATION LONGITUDE	
E RUN PROGRAM	9 STATION LATITUDE	

FLAGS 0 1 2 3 4 5 6 USED 7 8 9

TITLE GEOSTATIONARY SATELLITE BEARINGS PAGE 1 OF 1 — TI Programmable **Coding Form**

PROGRAMMER LARRY KUSHNER WA6BKC DATE JUNE 10, 1980

LOC	CODE	KEY	COMMENTS
0	76	LBL	
	11	A	
	42	STO	
	09	09	
	91	R/S	
	76	LBL	
	12	B	
	42	STO	
	08	08	
	91	R/S	
10	76	LBL	
	13	C	
	42	STO	
	07	07	
	91	R/S	
	76	LBL	
	14	D	
	43	RCL	
	06	06	
	91	R/S	
20	76	LBL	
	15	E	
	43	RCL	
	05	05	
	91	R/S	
	76	LBL	
	10	E′	
	02	INV	
	87	IFF	
	07	07	
30	05	CLR	
	32	X-T	
	43	RCL	
	08	08	
	88	DMS	
	75	-	
	43	RCL	
	07	07	
	95	=	
	42	STO	
40	03	03	
	39	COS	
	65	X	
	43	RCL	
	09	09	
	88	DMS	
	39	COS	
	95	=	
	32	INV	
	39	COS	
50	47	STO	
	04	04	
	67	EQ	
	01	01	
	33	33	
55	09	9	
	00	0	
	75	-	
	43	RCL	
	04	04	
60	95	=	
	38	SIN	
	75	-	
	93	.	
	01	1	
	05	5	
	01	1	
	03	3	
	95		
	55	/	
70	53	(	
	09	9	
	00	0	
	75	-	
	43	RCL	
	04	04	
	54	)	
	39	COS	
	95	=	
	22	INV	
80	30	TAN	
	58	FIX	
	01	01	
	52	EE	
	22	INV	
	52	EE	
	22	INV	
	58	FIX	
	42	STO	
	06	06	
90	43	RCL	
	09	09	
	88	DMS	
	30	TAN	
	55	/	
	43	RCL	
	09	09	
	94	+/-	
100	22	INV	
	39	COS	
	42	STO	
	05	05	
	39	COS	
	19	19	
	25	CLR	
	87	IFF	
	07	07	
	01	01	
110	41	41	
	43	RCL	
	03	03	
	77	GE	
	01	01	
	20	20	
	03	3	
	06	6	
	00	0	
	75	-	
120	43	RCL	
	05	05	
	95	=	
	58	FIX	
	01	01	
	52	EE	
	22	INV	
	52	EE	
	58	FIX	
130	61	GTO	
	01	01	
	49	49	
	00	0	
	42	STO	
	05	05	
	09	9	
	00	0	
	42	STO	
	06	06	
140	91	R/S	
	42	STO	
	05	05	
	77	GE	
	01	01	
	48	48	
	00	0	
	08	8	
	00	0	
	42	STO	
150	05	05	
	43	RCL	
	06	06	
	91	R/S	

MERGED CODES

62	72 (SBR)	83 (GTO)	
63	73 (RCL)	84	
64	74 (SUM)	92 (INV SBR)	

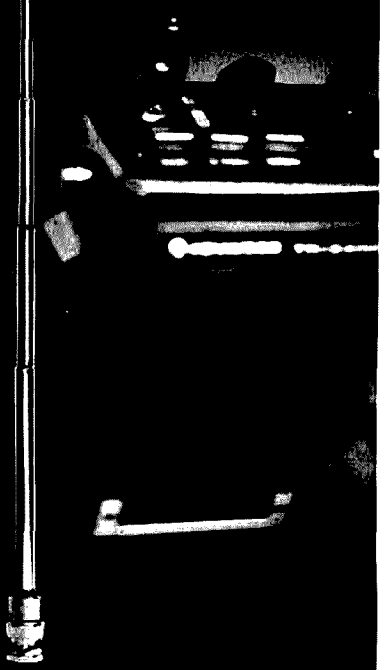
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CALIFORNIA: Santa Maria Amateur Radio Swapfest, June 14, 1981. Sponsored by the Satellite Amateur Radio Club. For info on prizes, swaptables, dinner tickets and much more, mail inquiries to: Santa Maria Swapfest, 1600 E. Clark #49, Santa Maria, CA 93455.

ILLINOIS: Radio Expo '81 sponsored by the Chicago FM Club will be held, rain or shine, on September 19th and 20th at the Lake County Fair Grounds, routes 45 and 120 in Grayslake. Grayslake is 30 minutes north of Chicago and 45 minutes south of Milwaukee. This year we will have a super large flea market with plenty of indoor and outdoor space, free with a gate ticket. Just bring your *own table and chair or* tailgate it. Parking is free. We will also have new camping sites complete with power hookups. There will be Ham seminars both Saturday and Sunday. YL's have a ladies program and door prizes both days. Only the best manufacturers of Ham and computer equipment and their distributors will be at our huge display building for you to meet and buy from. As in the past, Expo will be giving out thousands of dollars worth of prizes and admission tickets are good for both days. For advanced registration, send $3.00 per person and a #10 S.A.S.E. to Radio Expo Tickets, P.O. Box 1532, Evanston, Illinois. Tickets at the gate are $4.00 each. Kids under seven are free. For more information call (312) BST-EXPO. Talk-in on 146.16/.76, 146.52, and 222.5/224.10.

OHIO: The 12th annual B*A*S*H will be held on the Friday night of the Dayton Hamvention, April 24th at the Convention Center, Main and Fifth Streets. Admission is free. Food and C.O.D. bar. Live entertainment, super awards, and more. More info: Miami Valley FM Association, P.O. Box 263, Dayton, Ohio 45401.

OHIO: The Athens County A.R.A.'s annual Hamfest on May 17th at the Athens City Recreation Center, East State St. Talk-in on .34/.94. More info S.A.S.E. to: A.C.A.R.A., c/o Jeff White, WD8OXX, P.O. Box 767, Athens, Ohio 45701 or telephone Joe Follrod, WB8DOD (614) 797-4874.

ILLINOIS: 20th annual Moultrie A.R.K. hamfest on May 3rd at the Moultrie County 4-H center Fairgrounds. Talk-in on 146.94 and 146.055/.655. Write to M.A.R.K., P.O. Box 327, Mattoon, Illinois 61938.

INDIANA: The Wabash County A.R.C.'s 13th annual Hamfest on May 17th at the Wabash County 4-H Fairgrounds, Wabash. Talk-in on 7.83/.03 or .52 simplex. More info: S.A.S.E. to Dave Spangler, 45 Grant St., Wabash, Indiana 46992.

MASSACHUSETTS: South Shore Repeater Association's 5th annual auction on April 11th at the Central Junior High School, Broad St., Weymouth. Talk-in on 147.90/.30 machine. More info: S.A.S.E. to S.S.R.A., Town Hall Annex, 402 Essex St., Weymouth, Massachusetts 02188.

MASSACHUSETTS: Framingham Amateur Radio Association's annual Spring Flea Market on April 12th at the Framingham Police Station drill shed. Talk-in on .75/.15 and .52. More info: Ron Egalka, K1YHM, 3 Driscoll Dr., Framingham, Massachusetts 01701. (617) 877-4520.

MASSACHUSETTS: The Wellesley Amateur Radio Society's annual auction on April 18th at the Wellesley High School cafeteria on Rice St., Wellesley. Talk-in on .60/.03, .04/.64, and .52. Contact: Kevin P. Kelly, WA1YHV, 7 Lawnwood Pl., Charlestown, Massachusetts 02129.

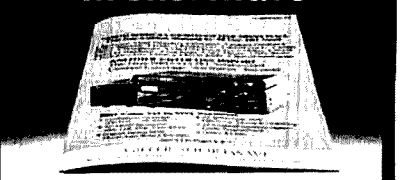
MASSACHUSETTS: The Middlesex Amateur Radio Club's first annual indoor flea market on April 26th at the Wayland High School Commons Building in Wayland. Talk-in on 147.96/.36 and 146.52 direct. Advanced reservations ($6.00) to Irving Goller, WA1CDW, Apt. 8422A, 1450 Worcester Rd., Framingham, Massachusetts 01701.

MINNESOTA: The North Area Repeater Association's swapfest and exposition for radio amateurs and computer hobbyists on May 30th at the Minnesota State Fairgrounds in St. Paul. Talk-in on .16/.76 and .52. More info: Amateur Fair, P.O. Box 30054, St. Paul, Minnesota 55175.

MISSOURI: The P.H.D. Radio Association's 12th annual Northwest Missouri Hamfest and Missouri State ARRL convention on April 11th and 12th at the Kansas City Trade Mart. More info: PHD Amateur Radio Association, Inc., P.O. Box 11, Liberty, MO 64068. (816) 453-4774 or 452-9321.

MISSOURI: Indian Foothills A.R.C. 6th annual Hamfest on May 17th at the Saline County Fairgrounds building in Marshall, Missouri. More info: Phyllis French, WØWIE, Route 4, Box 168, Sedalia, Missouri 65301. (816) 826-8319 after 5 P.M. or KØBVB at (816) 886-2837.

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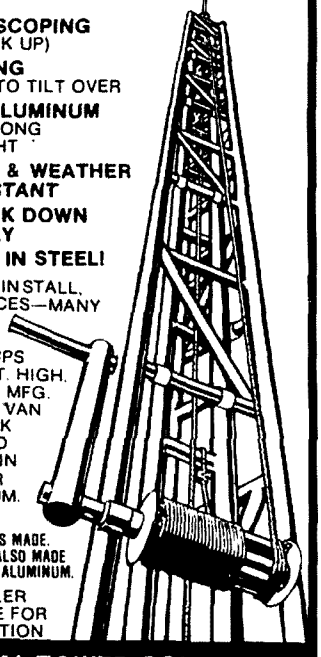
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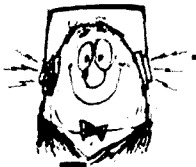


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COLORADO: The Rocky Mountain VHF Society's annual spring hamfest on May 17th at the Boulder National Guard armory, 4750 North Broadway. Talk-in on 146.16/.76 and 146.52. More info: Richard Ferguson, KA0DXM, 1150 Albion Rd., Boulder, Colorado 80303. (303) 499-2871.

CONNECTICUT: Fourth annual P.V.R.A. Flea Market on May 3rd at the George Penny High School in East Hartford, Connecticut. More info: Arnie, K1NFE, P.O. Drawer M, Plainville, Connecticut 06062.

FLORIDA: Annual "Conchfest" on May 16th and 17th featuring Conch Chowder, Conch Fritters, and a Conch Shell blowing contest. Tickets: $25.00/person and $15.00 for harmonics under twelve. Special rate at Sportsmen's Inn. More info: Key West A.R.C., P.O. Box 2371, Key West, Florida 33040.

ILLINOIS: The Rock River A.R.C.'s 15th annual hamfest on April 26th at the Lee County 4-H Center near Amboy. Talk-in, Dixon repeater .37/.97 simplex. More info: Chuck Randall, W9LDU, 1414 Ann Ave., Dixon, Illinois 81021. (815) 284-6380.

NEW ENGLAND: The Hosstraders will hold their Eighth Annual Tailgate Swapfest, Saturday, May 9, at the Deerfield, New Hampshire, Fairgrounds. Admission: one dollar, includes tailgating and commercial dealers. Profits benefit Boston Burns Unit of Shriners' Hospital for Crippled Children. Last year we donated $2058.16. Talk-in .52 and 146.40-147.00. Questions about New England's biggest flea market? SASE to Joe K1ROG, Star Route, Box 56, Bucksport, ME 04416, or Norm WA1IVB, RFD, Box 28, West Baldwin, ME 04091 or Bob W1GWU, Walton Rd., Seabrook, NH 03874.

NEW JERSEY: The 6th Trenton Computer Festival at Trenton State College, Trenton on April 25th and 26th. More info: TCF-81, Trenton State College, Hillwood Lakes, P.O. Box 940, Trenton, NJ 08625. (609) 771-2487.

NEW JERSEY: The DeVry Technical Institute WA2MDT A.R.C.'s 5th annual Amateur Radio and Computer Fleamarket on May 2nd at the DeVry Technical Institute, 479 Green St., Woodbridge, NJ. Talk-in on 146.52. More info call: Frank Koempel, WB2JKU, 634-3460 or Steve Hajducek, KA2IFX, 727-5962.

NEW YORK: The Southern Tier A.R.C.'s Hamfest on May 2nd on Route 17C, east of Owego. Talk-in on .16/.76 and .52. More info: D.R. Vasilow, W2EWO, Star Route 1, Box 35, Owego, NY 13827. (607) 687-1515.

NORTH CAROLINA: The Raleigh Amateur Radio Society's 9th annual Hamfest on April 12th at the Crabtree Valley Mall, U.S. 70 West, Raleigh. Talk-in (Saturday and Sunday) on 146.04/.64 and 146.28/.88. More info: R.A.R.S. Hamfest, P.O. Box 17124, Raleigh, NC 27619.

PENNSYLVANIA: Seventh Annual Northwestern Pennsylvania Hamfest, May 2, 1981, Crawford County Fairgrounds, Meadville, PA. Gates open 8 AM. Bring your own tables, $5 per table to display inside, $2 per car space outside. $3 admission, children under 12 free. Refreshments. Commercial displays welcome. Talk-in 04/64, 81/21, 63/03. Details C.A.R.S., P.O. Box 653, Meadville, PA 16335. Attn: Hamfest Committee.

PENNSYLVANIA: The Warminster A.R.C.'s 7th annual Ham Mart on May 3rd at the Middletown Grange Fairgrounds, Penns Park Rd., Penns Park. Talk-in on 146.52 simplex or W.A.R.C. repeater — 147.69/.09. More info: W.A.R.C., P.O. Box 113, Warminster, Pennsylvania or call Mark Hinkel, WA3QVU, (215) 657-7295.

SOUTH CAROLINA: The Blue Ridge A.R.S.'s annual hamfest on May 2nd and 3rd at the American Legion Fairgrounds, Highway 25 bypass in Greenville. More info S.A.S.E. to: B.R.A.R.S., 200 Walker Sp. Rd., Taylors, SC 29687.

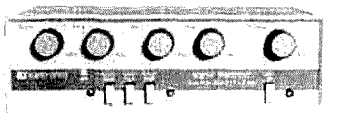
TENNESSEE: The first Tri-Cities Hamfest on May 2nd and 3rd at the Appalachian Fairgrounds in Gray. Sponsored by the Bristol, Johnson City, and Kingsport A.R.C.s. More info: Tri-Cities Hamfest, P.O. Box 3882 CRS, Johnson City, Tennessee 37601.

WASHINGTON: The Inland Empire Swapfest on April 25th at the Spokane Interstate Fairgrounds' Floral Building in Spokane. Talk-in on 146.34/.94 and 146.52 simplex. More info S.A.S.E. to: Swap Fest, c/o Jan Thieman, KA7DUU, 7803 E. Mission, Spokane, Washington 99206.

WISCONSIN: The Ozaukee Radio Club's annual indoor swapfest on May 9th at the Cedarburg Community Center Gym on Washington Ave., 22 miles north of Milwaukee. Talk-in on 146.37/.97 and 146.52. More info S.A.S.E. to: Ozaukee Radio Club, P.O. Box 13, Port Washington, Wisconsin 53074.

WISCONSIN: Green Bay Mike and Key Club's swapfest on May 17th at the Ashwaubenon Recreation Center, Anderson Dr. Talk-in on 147.72/.12 and 146.52. More info: Swapfest Chairman, Robert Duescher, 1011 13th Ave., Green Bay, Wisconsin 54304.

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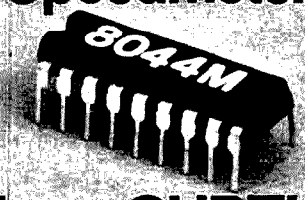


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OPERATING EVENTS

APRIL 24th - 26th: Special event station W8BI will operate from the Dayton A.R.A.'s communications van during the Dayton Hamvention. Certificates available, S.A.S.E. (large) to anyone contacting W8BI. Send QSL to W8BI, P.O. Box 44, Dayton, Ohio 45401. Frequencies: 14.295, 7.230, and 7.125 (CW). Times: 24th: 1800-2200 UTC; 25th: 1400-2200 UTC; and 26th: 1400-1800 UTC.

APRIL 24th - 26th: The St. Cloud MN ARC, in association with the city of St. Cloud, will issue a certificate to all amateurs who contact our special event station W0SV. Suggested frequencies 3.915, 14.305, 21.385, and 28.620 MHz. On phone listen for CO St. Cloud 125th Birthday. Send your QSL with S.A.S.E. to George Frederickson, KCØT, R.R. 2, Box 352, South Haven, MN 55382.

MAY 2nd AND 3rd: The L'Anse Creuse A.R.C. of Mount Clemens, Michigan will operate from the Mount Clemens Train Depot from 1400 UTC May 2nd to 2000 UTC May 3rd. Boyhood home of Thomas Edison. Operation will be 14 kHz from the bottom of the General phone bands, 40 kHz from the bottom of the General CW bands and 15 kHz from the top of the Novice bands using the call sign W8LC. Special 8½ x 11 QSL certificates will be available to all stations worked. QSL with a size 10 or larger S.A.S.E. to L'Anse A.R.C., W8LC, P.O. Box 72, Utica, Michigan 48087.

MAY 6th AND 7th: The New York State QSO party from *1700 UTC on May 6th to 0500 UTC on May 7th and from* 1200 UTC to 2359 UTC May 7th. Once on phone and once on CW. Signal report, serial number and New York county, state, providence or country. Phone: 3900, 7275, 14285, 21375, 28550. CW: 1810, 3560, 7060, 14060, 21060, 28060. Novice: 3725, 7125, 21125, 21825. Logs by June 16th. Send logs to: Mike Bucklaew, KA2KQP, 831 Dodge Rd., Getzville, NY 14068. Results S.A.S.E.

MAY 9th: Help us celebrate the Rogers, Arkansas Centennial Year on Saturday, May 9th, 1981 by working one of the Official Centennial Amateur Radio Stations. K5BP call letters will be used about 7,283 kHz LSB or 21,363 kHz USB from 1400 UTC to 2200 UTC. Send confirming QSL card with a #10 large S.A.S.E. to K5BP, Dept. 1881, Gen. Del., Rogers, Arkansas 72756 to receive an Official Centennial Certificate.

CENTURY 21 ARC — Low power — QRP'ers — CW nets — Contests — Awards — SASE KA4EBW.

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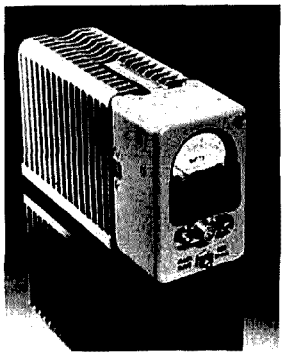
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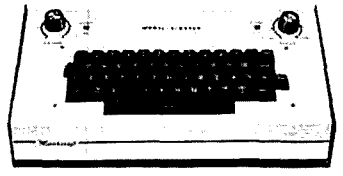
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NEW products



AEA CK-1 Morse Memory Keyer

Let's see. Paper, sharp pencils, check sheets, dupe log and coffee, plenty of it. It's Friday night, five minutes before the start of a 160-meter contest. I've finally got my station to the point that I feel I can be competitive with the big guns. But this year, I think I've got the edge on them. This year I have the new AEA CK-1 Morse Memory Keyer.

In past contests I've been limited to using a bug or straight key. Don't get me wrong, they're great to use, but in high-speed contesting I've never felt I was good enough to be competitive with them. Well, with all the new developments in chip technology, it was only a matter of time before some enterprising company designed a compact contest keyer. That company is Advanced Electronic Applications from Lynnwood, Washington.

description

The first impression one gets when opening the package is that instead of packing the CK-1 memory keyer, the dealer made a mistake and sent a pocket calculator. The keyer is extremely small, only 3.25 × 6 inches (8.3 × 15.2 cm) and very light, less than half a pound (0.22 kg). The layout is simple, with all switches, knobs and buttons easy to locate and operate. The keyboard is set up like a telephone Touch Tone™ pad. When you press the keys you get a positive feel, plus the keyer "bleeps" to let you know input has been made.

owner's manual

Probably the most important aspect of a product like this is the operating manual. Without a clear, concise set of instructions, operating the CK-1 would be impossible. AEA has gone to some time and trouble to put together one of the most complete instruction manuals I have ever seen. All keyer features are described completely, and all functions are explained step-by-step, with examples, so there can be no mistake when operating the keyer.

variable functions

One of my first thoughts was that since there was only one turnable control, you can't vary the sidetone, weighting, or speed. I was wrong. The CK-1 is like a microcomputer: you enter the appropriate data by hitting the appropriate sequence of numbers (buttons), and you can change the sidetone, weighting, or speed to whatever is most comfortable. You can also preset two speeds into the keyer. That's great when QSY'ing across the band and you want to either speed up or slow down.

memory

The most important operating feature of the AEA CK-1 is the variable-length memory. Ten separate memories can hold a total of approximately 500 characters. For the contest, I loaded a CQ into memory 1, signal report, section, and serial number into 2, and THANKS CU AGN into 3. Messages can be loaded in real time or automatically. In real time you send dots, dashes, and spaces. You've got to know exactly what you want to send, because if you pause, the CK-1 loads that pause. You can also load each memory automatically. When you stop sending, the memory stops loading information. This way, should you have any questions about what you're sending, you won't continue loading the keyer memory.

editing

Now, here is another real plus. Should you make a mistake, the CK-1 has an edit function that will eliminate the need to reload the entire memory. If you'd like to add something to an existing message, punch it up and let it run until you reach the point at which you'd like to add something. Stop the message by hitting either the paddle or # key. Set the keyer to MEMORY LOAD, press function keys * and 5, and, with the paddle, key in the change. Then switch back to MEMORY SEND and off you go again. To remove part of a message, set the keyer up as you would for an addition and run the memory to the point at which the deletion is to be made. Push * and 5 to program the keyer, then delete the remaining message. Just push # and it's done.

another feature

OK, now I have my CQ set up in memory 1, I've made memory 2 my RST, state, and serial number. Serial number? That's right. The CK-1 can automatically put an incremented serial number into any message register you'd like, 01 to 9999. To put the serial number into the keyer, load the message, then, at the point you want the serial number, push * and 0 and the serial number function is automatically initiated at 01. You can change that if you'd like to put any number in by pressing *, *, 0, then the four-digit serial number. Sounds complicated, but it's really simple, easy, and fun.

Aha — there's a CQ. "PA0HIP DE N1ACH," I flash with the paddle. Got him. Press memory 2 and off goes the CK-1 "DE N1ACH. UR 599 599 NH NH DE N1ACH BK." I hit memory 3 for a quick 73 and tune some more. I never knew a contest could be this much fun.

Craig Clark, N1ACH

600-MHz prescaler

The TP 600 is a high-sensitivity prescaler which will extend the upper frequency limit of most frequency meters by a factor of 10, up to a maximum of at least 600 MHz. Input and output are via 50-ohm BNC connectors. Input impedance is nominally 50 ohms and input sensitivity better than 10 mV from 40 MHz to 600 MHz.

Power requirements are 6 to 9 Vdc from an external power supply or optional ac adapter. A lead is supplied fitted with the correct connectors to allow the unit to be powered from the auxiliary power socket fitted to Thandar frequency meters. Current consumption is 150 mA nominal, 170 mA maximum. Case size is 4.5 inches (114 mm) × 1.70 inches (43 mm) × 1.10 inches (28 mm); weight is 4.3 ounces (120 grams). This unit is available from stock, price $98. For further information, contact Henrick K. Gille, Energy Electronic Products, 6060 Manchester Avenue, Los Angeles, California 90045.

vhf omni-match

The LAR VHF Omni-Match takes a wide range of inputs, making antenna/feed lines look like nonreactive 50 ohms. The unit lowers SWR, for bigger output. It's versatile in the 144-174 MHz range, with continuous coverage of Amateur, marine, and private mobile radio bands. No switching.

The Omni-Match gives whole-band coverage on narrow-band antennas such as Yagis and quads. Just tune out the SWR. It's simple to install and tuned in seconds with only two controls. Write direct or contact your dealer. LAR Modules Limited, 60 Green Road, Leeds LS6 4JP England.

squeeze wrench

To use the Squeeze Wrench, just hold it in a stationary position and squeeze. Its strong torque action gets the job done fast and securely. For reverse action, just flip it over; it ratchets in either direction. The Squeeze Wrench comes in a 22-piece kit that contains both standard and metric sizes. The complete kit includes the Squeeze Wrench itself (9/16 inch and 14 mm); five standard size sockets: 1/4, 5/16, 3/8, 7/16, and 1/2 inches; five metric sockets: 9, 10, 11, 12, and 13 mm; two standard slot screwdrivers; two Phillips screwdrivers; six Allen wrenches, and one adapter for use with screwdriver and Allen wrench heads. All working components are heat treated to the highest standards.

The Squeeze Wrench kit comes with a lifetime warranty and guarantee of complete satisfaction or money back. Price is $24.95 per kit, postpaid, from Howard Products Company, Dept. HR, P.O. Box 57246, Dallas, Texas 75207.

high-voltage power transistors

Motorola announces a new series of silicon power transistors which extends the power handling capability of its plastic encapsulated devices above the 100-watt level. The new Motorola devices are packaged in the JEDEC TO-218AC plastic package, which has a large die mount and heat sink area. Like the familiar but smaller TO-220 plastic package, the TO-218 offers the convenience of single-sided mounting, thus reducing assembly labor costs.

The new series of plastic devices to be introduced by Motorola are the MJE4340 and MJE4350 series. These are complementary transistors with a continuous collector current rating of 10 amperes. V_{CEO} ratings range from 100 to 160 volts, and dissipate 125 watts. Contact Motorola Semiconductor Products, Inc., P.O. Box 20912, Phoenix, Arizona 85036.

ac power line protector

The series 2000 ac power line protector protects an entire facility from damage due to lightning and transient overvoltages. Protection is provided without power interruption. The protectors install at the main service panel (load side) and provide heavy-duty protection from lightning and transients that occur in tough industrial environments.

Operating in nanoseconds, the shunt-connected 2000 series protectors will vigorously clamp lightning and transient overvoltages on the ac lines to safe levels whenever the clamping threshold is exceeded. After each transient the protector recovers automatically — without power interruption. Nuisance circuit breaker tripping, so common with gas arrestors and crowbar devices, is eliminated. The 2000 series can withstand thousands of severe surges without degradation of electrical performance.

Long life and maintenance-free operation also make these units the perfect protector for remote and unattended stations, for facilities, or stations with no backup capabilities. The protectors are enclosed in a moisture-proof housing to ensure reliable operation in any environmental condition. Contact MCG, 160 Brook Avenue, Deer Park, New York 11729.

quartz digital clocks

Benjamin Michael Industries, Inc., announces the addition of the 173D Presentation Model clock to its line of quartz digital timepieces. The 173D contains two independent digital electronic clock movements. Greenwich Mean Time is displayed in 24-hour format on one clock and 12-hour time with AM/PM indicators on the other. Both large displays are of the LCD type. The 173D features quartz crystal accuracy along with one year of operation on a single, standard penlight battery. The clock features a solid walnut case which accentuates the rough cut, gold anodized, brushed aluminum face plate. Precious metal contact switches and brass hardware are used throughout.

The model 173D sells for $119.95 with keyways for wall mounting. A matching walnut desk stand may be ordered for an additional $9.95. Delivery is from stock within four weeks

Contact Benjamin Michael Industries, Inc., 65 East Palatine Road, Prospect Heights, Illinois 60070.

heavy duty towers

Designed especially with the ham operator in mind, Aluma Tower's new extra-heavy-duty aluminum tower has uprights and cross braces of 1-inch seamless drawn aluminum tubing, with stainless-steel aircraft cable connecting the telescoping sections. The mast is 2 inches in diameter × 8 feet long and is supplied bolted in place.

Aluma Tower's telescoping construction and tilt-up style enables it to withstand any weather conditions. Write Aluma Tower Company, 1639 Old Dixie Highway, Vero Beach, Florida 32960.

small-signal, low-noise transistors

TRW RF Semiconductors has published a new catalog containing detailed information on its family of 15 small-signal, low-noise transistors. Catalog 80 is a 52-page booklet that contains specifications, performance graphs, photographs, circuit diagrams, and package drawings and dimensions. All devices in the catalog are NPN silicon bipolar transistors with gold metallization.

Copies are available from any authorized TRW RF Semiconductors distributor or from Bernie Lindgren, Sales Manager, TRW RF Semiconductors, 14520 Aviation Boulevard, Lawndale, California 90260.

short-form rf catalog

TRW RF Semiconductors has published a large-format, 12-page, short-form catalog, number 503A, that lists basic specfications for 156 components.

Ten categories of products are shown, along with photographs and engineering drawings of each package type. There are an alphanumeric ndex and a cross-reference table.

Copies are available from any TRW RF Semiconductors sales office or authorized distributor, or from Dan Faigenblat, TRW RF Semiconductors, 14520 Aviation Boulevard, Lawndale, California 90260.

five-mode terminal

A five-mode sending terminal, by Curtis Electro Devices, offers keyboard origination of Morse, ASCII, and Baudot codes in addition to being a paddle keyer, code practice generator, and contest memory unit.

Features include a 256-key sending buffer and a 256-key soft sectored message memory with up to four call-ups. The two-key lockout and fully debounced keyboard offers all domestic, European, and many commercial prosigns for CW, all Baudot characters and upper and lower ASCII communications characters. Automatic line length control, word wrap-around, hold, and backspace make sending easy and error-free. All LTRS and FIGS shifts are automatic in the Baudot mode.

Pot controls are provided for speed, weight, pitch, and volume, together with meter displays of Morse speed and buffer status. Output is via mercury relays for the keyline and PTT (or KOS) line. RTTY output is a loop switch. The message memories include three fixed preambles (CQ, CQ TEST, ID and QRS) plus up to four programmable memories.

Powered by either ac or + 12 Vdc, the KB-4900 measures 12 × 8½ × 4½ inches and weighs 5 pounds. It is priced at $379.95 FOB the factory. Write Curtis Electro Devices, Inc., Box 4090, Mountain View, California 94040.

speech compressor/ expander

VSC Corporation has introduced the VSC Model AV3, which uses the Wollensak Bi-Peripheral Drive to insure long-term, reliable performance. A simple movement of the VSC speed control lever plays any standard audio cassette from 60 percent

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VSC speed listening is used by students, businessmen, and professionals who review recorded lectures, meetings, notes, professional updates, and dictation. The technology provides them with the flexibility to absorb recorded speech faster than the average person reads. Research shows that faster speeds increase concentration, which in turn improves comprehension. Additionally, the Model AV3 can provide high-speed inspection of printed circuit boards, wire wrapping matrices, cable harnesses and pin connections. Most importantly, VSC has virtually eliminated all proofing errors. The VSC Corporation expects the VSC feature to become popular on a wide array of audio equipment, including hand-held cassette players, auto cassette decks, telephone answering machines, dictating/transcribing units, and film and video editing equipment.

The Model AV3 offers separate tone control to adjust sound for maximum clarity and comfort, cue and review, digital tape counter, and remote pause control. An open cassette chamber makes loading a breeze and readily accepts minicassette adapters. Headphone, microphone and foot pedal jacks are included. The compact and impact-resistant speech compressor/expander comes with a handle and locking cover for easy portability and storage. This top-of-the-line VSC unit weighs 8.5 pounds and is available for $495 from VSC, 185 Berry Street, San Francisco, California 94107.

512-MHz digital frequency counter

Heath Company has announced the introduction of a new 512-MHz portable frequency counter, available either in kit form or assembled. The IM-2420 features four gate times and eight-digit resolution for precise readings. A period function gives cycle time in seconds, while the frequency ratio function provides the ratio between two input frequencies.

For more accurate measurements, a standby power switch can keep the crystal oven warm for maximum frequency accuracy. The oven is proportionally controlled to keep the internal time base within 0.1 part per million over a wide temperature range. The IM-2420 also has provisions for using external time base signals. Four gate times and a large, 0.43-inch-high, eight-digit LED display provide the resolution necessary to measure UHF signals. The IM-2420's 4-15 mV typical sensitivity allows counting of low-level signals. Trigger level control ensures stable counting when noise is present, and provides more accurate measurement of complicated waveforms. Frequency measurements can be made by direct connection, or by using the optional SMA-2400-1 swiveling telescopic antenna. The IM-2420 frequency counter can be wired for either 120 or 240 Vac operation.

The Heathkit IM-2420 512-MHz frequency counter is mail order priced at $239.95, F.O.B. Benton Harbor, Michigan 49022. A factory assembled and tested version, SM-2420, is also available, mail order priced at $299.95. Write Heath Company, Dept. 350-660, Benton Harbor, Michigan 49022. In Canada, write Heath Company, 1480 Dundas Highway East, Mississauga, Ontario L4X 2R7.

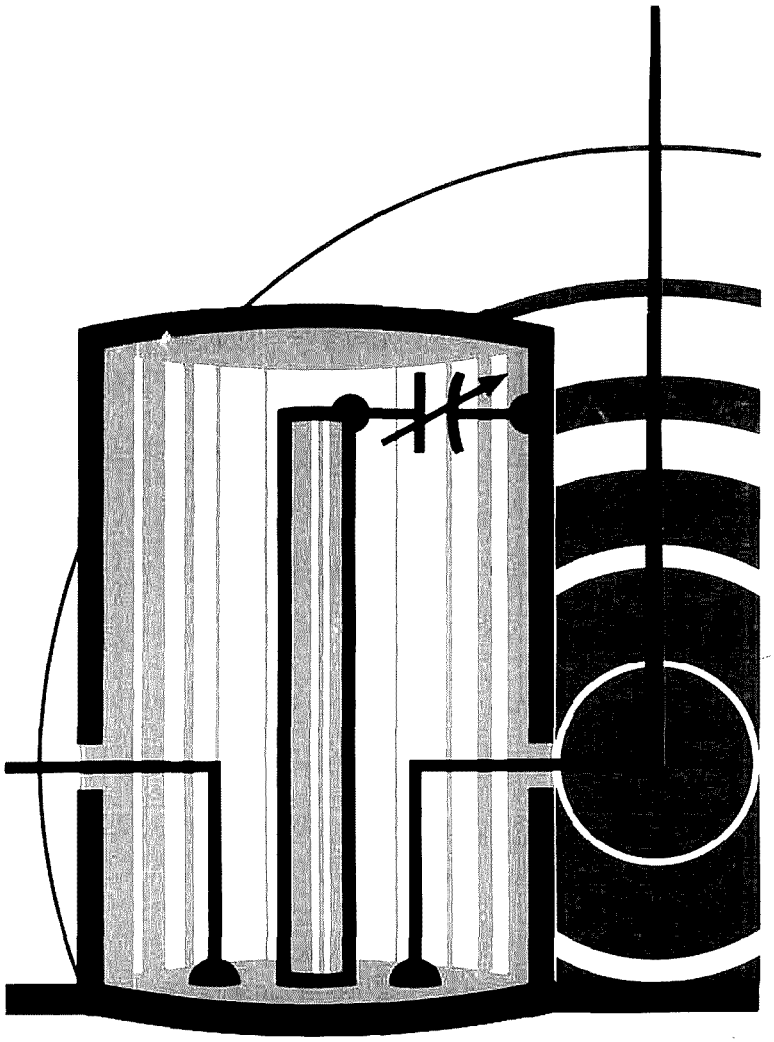
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MAY 1981

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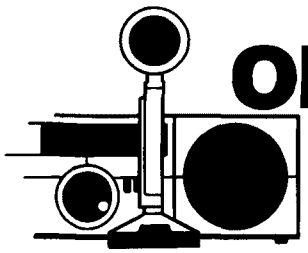
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Observation & Opinion

Here it is — our annual antenna issue. A great deal of care and planning has gone into this issue. We think the selection of articles is sufficiently well balanced to please everyone interested in antennas. And since it's hard to get on the air without an antenna, that should be just about all of our readers.

Our feature article describes a resonant reentrant cavity antenna, designed and patented by Bill Tucker, W4FXE. A thorough treatment of the theory of this antenna is given, followed by a discussion on how to build an experimental, basic cavity whose enclosure, of all things, is an ordinary coffee can. This antenna appears to furnish the answer to the problem of VHF-UHF receiver desense and intermod distortion, which is caused by out-of-band signals.

You'll also find in this issue articles on how to build two simple but very effective beam antennas from easy-to-find materials. They are so simple that just about anyone can put them together in a day or two at most — surely a pleasant way to spend a spring weekend.

And there's a surprise in this issue. It's something that has never been attempted in *ham radio*. Maybe I'm sticking my neck out, but somehow I have a feeling that the story of "Jim" will be a welcome change of pace. Let me know how you like it. If your response is positive, we'll have some more stories by old-timer John Flippin, W4VT.

A good barometer of how readers like *ham radio* was the ARRL National Convention at Orlando, Florida. Our booth at the convention was virtually besieged by Amateurs. Orlando was my first such show experience as editor, and it gave me the opportunity to meet a cross section of our readership. I want to thank everyone who took the time to offer comments. A great many expressed their compliments on the new *ham radio*. Of course there were some complaints too, but the number of positive remarks was greater than the complaints by an order of magnitude. I was greatly impressed by the enthusiasm of the crowd, which must have numbered in the thousands. I had a chance to meet some authors in person and exchange ideas for new articles. I wanted to circulate and take in some of the technical presentations, but business was so brisk at the *ham radio* booth that I didn't have a chance. Perhaps at Dayton!

The people at a large convention are most interesting. Young hams with 2-meter handhelds talking to each other across the room through the local repeaters; handicapped fellows in wheelchairs trying to see through the crowd; proud dads and their sons wearing identical T shirts with their callsigns displayed on the back; the fellow from a southern ham club wearing a red vest festooned with ribbons, badges, embroidered patches, Civil War medals, and his call sign spelled out in ¼-watt resistors. Then there was the fellow sporting a huge stovepipe hat with a miniature three-element Yagi beam on top, powered by a small electric motor. And last but not least, there was the youngster who bent my ear for a half hour asking for help in selecting study material for his Novice license (I fixed him up with some).

All in all, it was a rewarding experience and I wouldn't have missed it for anything. Those who forecast the demise of Amateur Radio should come out of their shells and take in one of the large conventions. Our future certainly looks healthy and hearty to me.

Alf Wilson, W6NIF
Editor



comments

Dear HR:

Responding to your editorial in *ham radio*, December, 1980: The Bash situation is distasteful to many of us, but the practicalities of the situation remain. Memory plays a considerable part in all FCC exams, particularly Novice and Tech/General. There is no way to rationalize the FCC's rules and regulations — one must memorize them.

Let's face it, the majority of hams will not contribute to the technical advancement of Amateur Radio. (This is not to say that many non-technicals do not contribute greatly to the advancement of ham communications, emergency and otherwise.) For years, FCC-type exam questions were published and answers given out, even by the ARRL. So why not revert to this system — have the FCC change their present format and have many, many questions that could be used in the exams? Publish them and give the answers. One could not very well memorize them all, and, indeed, if anyone did, he would have quite a knowledge of radio and electronics.

Harry A. Lord, K4QJ
Palmetto, Florida

Dear HR:

Congratulations on your editorial in the December issue on the West Coast publisher who solicits and sells FCC exam information.

Since June, I have written to the FCC, to *Worldradio*, and, most recently, to Senator Goldwater on this very topic, which I, too, consider to be a serious threat to Amateur Radio as we know and esteem it. I feel, however, that there has already been too much time wasted in discussion of this problem in ham publications. The time has come for action.

I therefore encourage all hams who share our concern to write to Senator Barry M. Goldwater, Senate Office Building, Washington, D.C. 20510 and to their own representatives in Washington, urging legislation which would prohibit solicitation and divulgence of federal exam information, and provide specific penalties for such activities.

Paul Ellis, KN6D
Santa Cruz, California

Dear HR:

I read with interest your editorial of December, 1980, concerning FCC exams. The publisher of the exam questions and answers is doing little more than what the ARRL has done for years. I recall in the late 1950s, when I was in high school, my friend and I studied for and passed the exams for Novice and General licenses by using flashcards prepared from the ARRL *License Manual*. We memorized the answers and passed the tests, and we learned in the process.

Since then, I've passed the exams for Amateur Extra Class, 2nd Class Radiotelegraph, and 1st Class Radiotelephone. I have built transmitters and test equipment and am working on a high-frequency synthesizer. Electronics is a complex and difficult science, and people who are trained in it often seem to forget the energy and time they devoted to their training. For those of us with no training, it is impossible to thoroughly study basic electronics in the hope that we will learn what we need to pass the test. FCC exams *should* be designed so that, through memorization, those who take the tests will learn what they need to know to competently operate a station and to have an idea how to fix one. Most Amateurs learn more after the ticket comes, by operating a station and maintaining it. Only a few Amateurs (usually with formal training) will make a contribution to the art. Amateur Radio is more effective in allowing thousands of untrained hams an opportunity to learn through experience. Your magazine is excellent. I understand only half of the articles, but I'm learning!

Dave Moorman, K9SW
Downers Grove, Illinois

Dear HR:

Reading your latest Observation and Opinion, I immediately thought of the licensing system in West Germany. You may complain about an individual Amateur. We over here should complain about the communications administration in this country, as they publish a brochure containing questions and answers concerning the Amateur license exams. These booklets were originally meant to provide a certain help to the examining committee (most of them usually non-Amateurs) but are available to the public as well. Making it even worse, most of the time the questions used in exams are exactly the same as those in this official publication. In some cases, even the values of voltage and current in some basic Ohm's-law calculations were not even changed.

This leads to an entirely new type of Radio Amateur, which we could better call a "person licensed to participate on Amateur frequencies." The majority of these people can be found on 2-meter VHF (mainly fm), as this band requires no code test. Also, quite a lot of them are ex-CBers (from an absolutely saturated 12-channel CB band).

Although the situation in the U.S. is much different from the one over here, I agree with your opinion that memorizing questions and answers is definitely not the right way to get a license. I could list enough examples of the outcome of that type of preparation to fill another letter, but I should say you should be aware about the aftermath. It seems much better to stop things like that right in the beginning than to try to teach people after they receive their license.

Gerhard Petri, DF7BL
West Germany

presstop

SPREAD SPECTRUM HAS BEEN OK'ed for experimental use on a number of Amateur bands. An FCC Special Temporary Authorization agreeing to a proposal by AMRAD (the Amateur Radio Research and Development Corporation), was handed to W4RI and WB3KDU on Thursday, March 6. It grants them and 23 other members of AMRAD permission to conduct experiments using the revolutionary broadband modulation technique for a one-year period on both HF and UHF frequencies.

Four Different Experiments were proposed in the AMRAD request, and all were authorized in the FCC's STA. The first is for HF "frequency hopping," with the band determined by propagation at a given time. Frequencies authorized are 3675-3775 kHz, 7050-7150 kHz, or 14100-14200 kHz. "Service frequencies," where pre-test CW or SSB announcements and other conventional-mode traffic will be handled will be 3725, 7100, and 14150 +10 kHz.

10 Meters Will Be Used for the second experiment, also using frequency hopping between 28.1 and 29.3 MHz. The third experiment is a UHF "direct sequence" operation, utilizing 420-431 and 438-442 MHz to avoid possible conflicts with weak signal, OSCAR or FM users. Coordinated experiments with area ATV'ers and the Metrovision ATV group are planned. An E-M-E spread-spectrum experiment is also planned, operating on 432 MHz with bandwidths of from 16 kHz up to a megahertz.

Prior Warning Of The HF spread-spectrum operations is planned via W1AW and HR Report.

DIRE CONSEQUENCES FROM FCC budget cuts were spelled out by Acting Chairman Bob Lee in Capitol Hill testimony March 10. For private radio he noted the rules updating program (Plain Language Amateur Rules) would see serious delays, and that Amateur (and CB) license turn-around could slip from present 14-41 days to over two months. Rules enforcement efforts would also be reduced.

Field Offices Would Be Closed in Beaumont, Texas; Savannah, Georgia; Cincinnati; and Pittsburg. Also closed will be the Anchorage Monitoring Station and the two Special Enforcement Teams that operate in Powder Springs, Georgia, and in Detroit. Finally, Lee predicted that the traveling exam program, now covering 77 cities monthly, quarterly, or annually, would become entirely annual.

A RAISE IN DUES TO $25 and League General Manager Dick Baldwin's announcement that he plans to retire next year were two of the highlights of the ARRL Board meeting in Orlando March 11-12. Though the League has operated in the black the past two years, rising costs and projections for the near future convinced the directors that the increase in dues was necessary. It's to become effective July 1, and until then annual members can extend their memberships at the present $18 rate. Members over 65 will get a break after July 1, a 20% discount on their dues.

The Ad Hoc Committee On Ethics presented an extensive report on suggested conduct in future League elections, which was adopted by the board. They also agreed on a new bylaw establishing a procedure for recalling a League director. Expansion of General-class 75-meter phone privileges down to 3825 was proposed, but referred to the Plans and Programs Committee for study.

The Board Also Voted to discourage contest and awards use of the new 10.1-10.15 MHz band while it remains shared, and to petition the FCC to reinstitute issuance of the club station licenses.

MICROWAVE RADIATION KILLED a New York telephone company supervisor, the state's Workers' Compensation Board ruled recently in a decision believed to be the first official finding of its kind. The supervisor, who worked with TV relay equipment on the Empire State Building's 87th floor, died of "abnormal, premature aging" according to Dr. Milton Zaret, radiation specialist and professor at NYU Medical School. The supervisor, who lost his sight, hair, and coordination before dying at 58, had worked at the Empire State installation for eight years.

NEW REPEATERS NEAR THE NATIONAL Radio Astronomy Observatory and Naval Research Laboratory facilities must coordinate with the observatory and lab authorities, the Commission agreed recently. The action, which extends existing sanctions to Amateur repeaters in the quiet zone straddling the Virginia/West Virginia border and surrounding Green Bank and Sugar Grove, Virginia, applies only to new repeaters or modifications of existing machines. No already operating repeater, individual Amateur station, or mobile passing through the area is affected.

NEW CLUB STATION LICENSES are still a dead issue following the FCC agenda meeting March 26. A Petition for Reconsideration of Docket 21135, asking for new club station licenses and filed by the Capitol Hill ARS, was dismissed at the meeting without discussion.

Any Club Whose Amateur License has been lost since the ban on new club licenses began in 1977 should contact Perry Williams at ARRL. He plans to discuss such cases with the Commission shortly.

re-entrant cavity antenna for the VHF bands

Ideas for the experimenter interested in mobile antennas

This article introduces the Radio Amateur to a recently patented UHF-VHF mobile whip antenna* of unique design, the answer to the "intermod alley" problem that has plagued 2-meter mobile operation. While not precisely a construction article, this paper provides sufficient background for experimentation and construction.

Amateur Radio operators have had to contend with the steadily increasing problem of interference ever since the early days of radio communications. New designs and inventions have been steadily introduced to reduce or eliminate the various types of interference that have appeared.

With the greatly increased use of 2-meter mobile operation in recent years, intermod and desensitivity have been major problems, especially because of the closeness in frequency of neighboring commercial bands. The problem is not, by any means, unique to Amateur Radio; it's just as troublesome to commercial two-way radio.

Because the frequencies most widely used by Radio Amateurs for mobile operations are in the 2-meter band, all references and discussions relate to this band unless otherwise indicated. However, the principles and practices may be applied to all VHF-UHF bands, both Amateur and commercial.

interference

Critical voltage and current levels exist in the front end stages of the receiver section of the typical mobile transceiver. A strong local signal, even far removed in frequency, can get into the front end and upset those critical levels, causing considerable degradation in receiver sensitivity. This phenomenon is known as overloading or blocking and is referred to as desensitization, or *desense*. It is very common in VHF mobiles operating in metropolitan and industrial areas.

Another serious type of interference that plagues VHF mobile radio is intermodulation distortion, or *intermod*. This problem occurs when two or more strong local signals of different frequencies invade the front end of the transceiver receiver section, which is a nonlinear device capable of mixing, producing one or more new signals. If one of the new signals falls on or near the frequency being received, interference will result in the form of crosstalk or peculiar noises and, in many cases, will completely obliterate the desired signal.

A major source of intermod and desense in the 2-meter band is from the 150-170 MHz band, which is used extensively by commercial and governmental services. This problem is especially acute in the business areas of large cities, where certain sections have been dubbed "intermod alley."

Image frequency is sometimes a problem where the Radio Amateur is operating mobile in the vicinity of an airport. It's apparent that, with a 10.7-MHz i-f and a local oscillator that can be varied between 133.3 and 137.3 MHz, air traffic on frequencies between 122.6 and 126.6 MHz could get into the receiver front end and cause interference in the 2-meter band.

Often, interference may result when the mobile radio is in the strong-signal area of high-powered TV and fm broadcast stations whose frequencies are far removed from the 2-meter band. This interference occurs when the sum or difference frequencies of the two broadcast stations fall on or near the received frequency in the 2-meter band. Example: The mobile antenna receives both the video signal of TV channel 2 (55.25 MHz) and the audio signal of an fm station (91.3 MHz). Both signals mix in the receiver front end and produce an interfering signal on 146.55 MHz in the form of a broad, garbled audio mixed with video hash.

The examples mentioned above represent only a few of the many interference-causing combinations that might exist. All have one thing in common:

By William Tucker, W4FXE, 1965 South Ocean Drive, Apt. 15G, Hallandale, Florida 33009

*U.S. Patent 4,128,840, December 5, 1978. For those wishing copies of the patent, I will supply eight-page copies for $1.00 postpaid in the U.S.A.

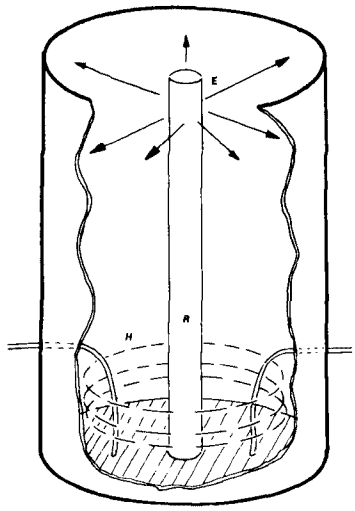


fig. 1. Concentration of magnetic field, *H*, and electric field, *E*, in a resonant cavity with a re-entrant section, *R*.

they're caused by unwanted out-of-band signals received by an antenna and fed to a vulnerable receiver *front end*.

countermeasures

The majority of transmitting and receiving antennas used in UHF-VHF mobile service are broadband. Although resonant at one frequency or band of frequencies, the antenna will receive signals far removed in frequency and feed them through the coax line to the receiver. The method of keeping such signals out of the receiver front end is to use highly selective bandpass filters. Not much can be done to keep unwanted in-band signals out, as the bandpass filter and the receiver front end are usually designed to accommodate the entire desired band.

At VHF or UHF, to obtain the high *Q* necessary for effective bandpass filtering, conventional lumped-constant components, such as coils and capacitors, will not suffice. The designer must resort to cavity resonant circuits (discussed later).

Manufacturers of Amateur Radio equipment have recognized the severity of the interference problem and have incorporated into their transceivers a hybrid cavity bandpass filter known as the *helical resonator*. This filter has helped the situation. However, in many cases, manufacturing engineering compromises leave something to be desired.

Helical resonators have gained wide acceptance because of their small size and the fact that they can be mounted directly onto the PC board close to the receiver front end. While this bandpass filter is effective in attenuating out-of-band signals that arrive through the antenna, very strong signals may still find their way into a vulnerable front end because of the closeness of the resonators to sensitive circuitry.

resonant re-entrant cavity

A resonant cavity *is an enclosure, or partial* enclosure, of any size or shape with conducting walls or surfaces that can support oscillating electromagnetic fields within it. It will have certain resonant frequencies when excited by radio-frequency currents. The basic paper on cavity resonators was written by Hansen in 1938.[1] When such an enclosure includes a re-entrant section, the electrical and magnetic fields tend to concentrate in different parts of the cavity, thereby relating to a circuit with lumped constants. The magnetic field is concentrated around the re-entrant section base, and the electric field is at a maximum at the open end, fig. 1.

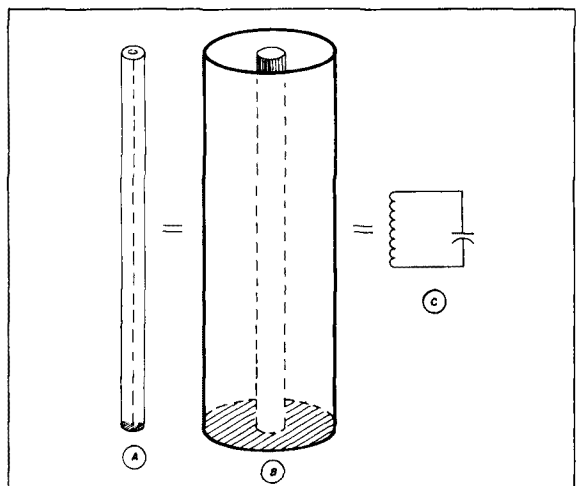


fig. 2. Quarter-wavelength coaxial cable (*A*) and re-entrant cavity (*B*), both short-circuited at one end, is equivalent to a parallel resonant circuit (*C*).

Quarter-wavelength cavity. A quarter wavelength of coaxial cable or concentric transmission line short-circuited at one end has properties similar to those of a parallel-resonant circuit. The resonant re-entrant cavity can be considered a wide-diameter section of concentric transmission line short circuited at one end with air as the dielectric, fig. 2. This type of cavity has been used as a very high *Q* coaxial tank circuit in VHF-UHF transmitters and has been widely used as a bandpass filter.

At the short-circuited end of a re-entrant cavity, rf current is maximum, requiring very high conductivity surfaces and a very low rf resistance connection

between inner and outer conductors. Because of the prevalence of skin-effect at VHF and UHF, a surface plating of copper or silver is often used to ensure high conductivity, resulting in high Q throughout the cavity interior surfaces. In all discussions relating to re-entrant cavities, references to the outer conductor or housing indicates the interior surface only; references to the inner conductor indicates outer surface only. The housing exterior and the inner-conductor interior (if tubing is used) are cold insofar as rf is concerned and are at ground potential.

A very high impedance exists at the open end of the re-entrant cavity and is an area of high rf voltage. Where insulation is required in this area, great care must be used in the choice of low-loss material to prevent degradation of the very high Q.

It's desirable, from an optimum-Q standpoint, to make the center conductor of a resonant re-entrant cavity a *full* quarter wavelength. The frequency may then be adjusted by varying the conductor length within the cavity housing. In cases where the center conductor and its housing must be made shorter than a quarter wavelength, both will present an inductive reactance and will require the addition of capacitive reactance to achieve resonance.

In practice, this is readily accomplished by adding a capacitor across the open end of the cavity. Of course, using a variable capacitor makes it convenient to adjust this shortened length to the desired frequency, **fig. 3**. Actually, the physical length of a quarter wavelength center conductor is less than its electrical length because of the shunting effect of the stray capacitance that exists due to the proximity of the housing to the open end of the center conductor. It is axiomatic that, as frequency is increased, the optimum length of the cavity can be decreased.

While the cavity length and its inner conductor determine frequency, the outer-conductor diameter and its ratio to the inner conductor are important in determining optimum Q. According to Terman,[2] a ratio of 3.6 is considered optimum and, while maintaining that ratio, a further increase in Q is directly proportional to an increase in outer-conductor diameter within practical limits.

Half-wavelength cavity. The resonant re-entrant cavity may also be designed as a half-wavelength device, which also can be shortened by capacitive loading, **fig. 4**. In this design, which becomes practical as frequency is increased into the UHF range, the principles and practices are similar to those regarding

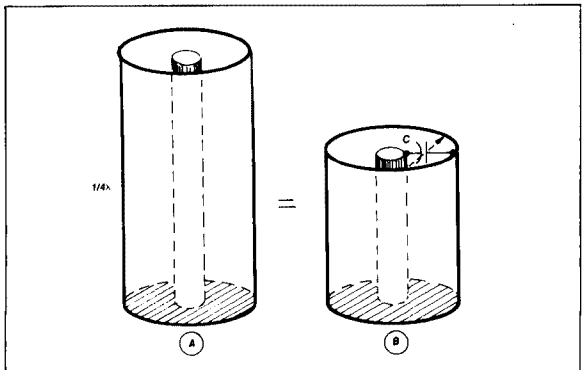


fig. 3. Quarter-wavelength resonant re-entrant cavity (*A*) shortened at (*B*) using capacitive loading to resonate to same frequency.

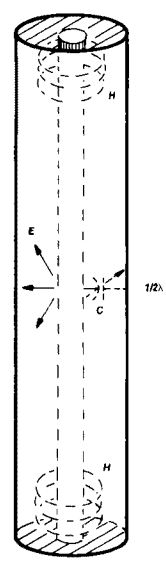


fig. 4. Half-wavelength resonant re-entrant cavity. Magnetic field, H, is at both short-circuited ends; electric field, E, is at center. Device is tuned to resonance by capacitor C.

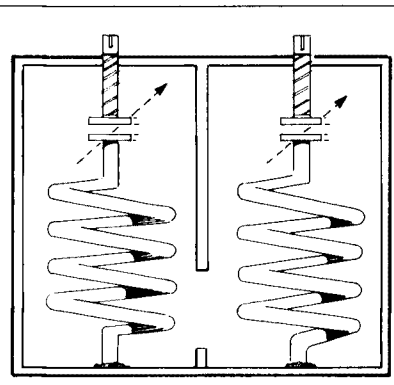


fig. 5. Helical resonator: a hybrid resonant re-entrant cavity.

the quarter-wavelength cavity. In the half-wavelength version, the two short-circuited ends are high current areas, while the center is the point of high voltage, where a variable capacitor is used to tune the cavity to resonance. Note that a 3/4-wavelength cavity has characteristics similar to those of the more widely used 1/4-wavelength cavity.

Helical resonator. The helical resonator (**fig. 5**) is a hybrid re-entrant cavity in which the center conductor has been shortened into the form of a helix placed inside a small cavity housing. While the Q of this hybrid is less than that of the conventional larger-size cavity, two or more can be cascaded in a small space to provide increased skirt selectivity with a broader bandpass characteristic. The design of helical resonators has been fully covered in another article.[3] For those who wish to investigate further, an original paper was presented by Macalpine and Schildknecht,[4] followed by several other important papers.[5,6] The RSGB *VHF-UHF Manual* also covers the subject quite well.

Re-entrant cavities and their many hybrids have been designed in many different shapes and sizes. They are referred to as coaxial filters, cavity bandpass filters, trough-lines, striplines, microstriplines, comblines, interdigitals, and helicals. They have one thing in common: all are in the re-entrant cavity family.

coupling

The manner and magnitude in which rf energy is coupled into and out of a resonant re-entrant cavity plays an important role in determining the selectivity, insertion loss, and impedance; all are interrelated.

Coupling may be accomplished by three basic methods; electromagnetic coupling using pickup loops, electrostatic coupling using capacity probes, and by direct connection to the inner conductor. A combination of these may be used, depending on the specific application.

When dealing with low impedances such as encountered with coaxial-cable transmission lines,

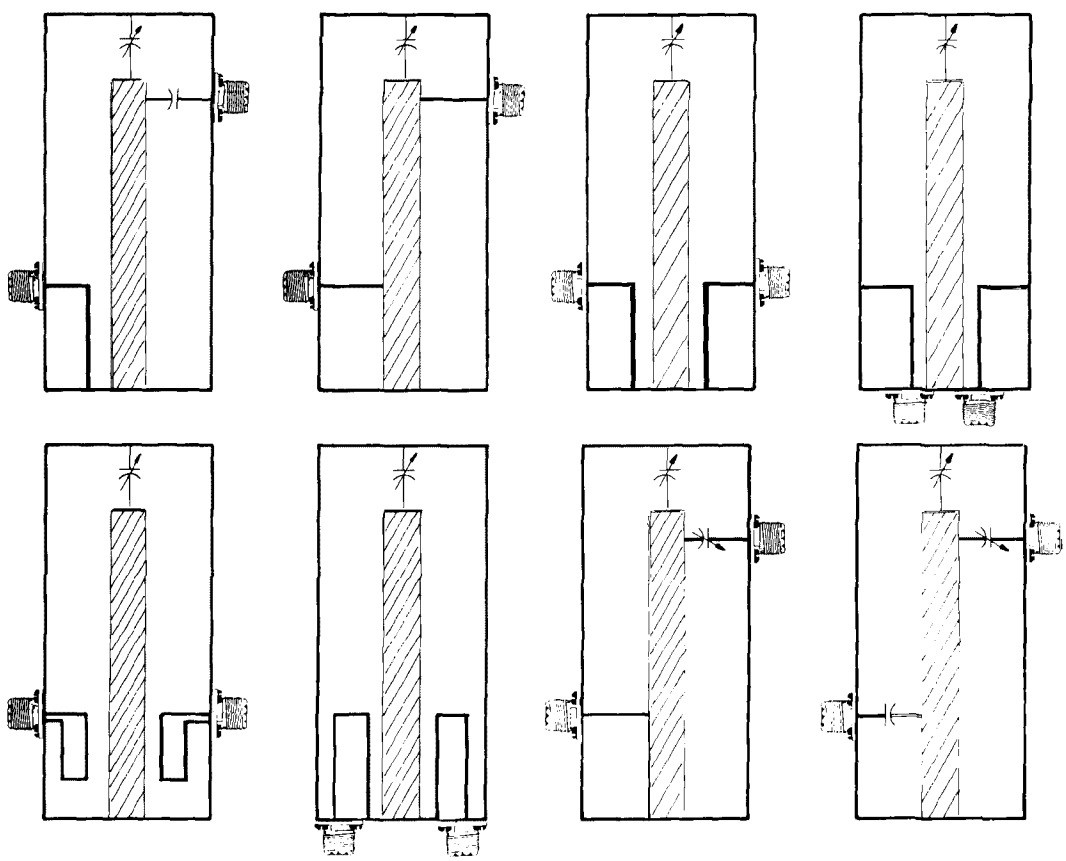


fig. 6. Coupling design for resonant re-entrant cavities.

pickup loops are usually used. In some cases, direct connection to low-impedance positions on the inner conductor is used, especially where cavities are connected in cascade. Capacitive probes provide a convenient method of feeding energy to or from high-impedance circuits. Some coupling configurations are shown in fig. 6.

Insertion loss. The insertion loss in a resonant re-entrant cavity depends on several factors, which include the cavity size, type of materials used in the construction, and the type and degree of coupling. Close coupling will decrease the insertion loss but will adversely affect selectivity; conversely, loose coupling will have the opposite effect.

Pickup loops are usually placed in the area of the high electromagnetic field, which exists at the short-

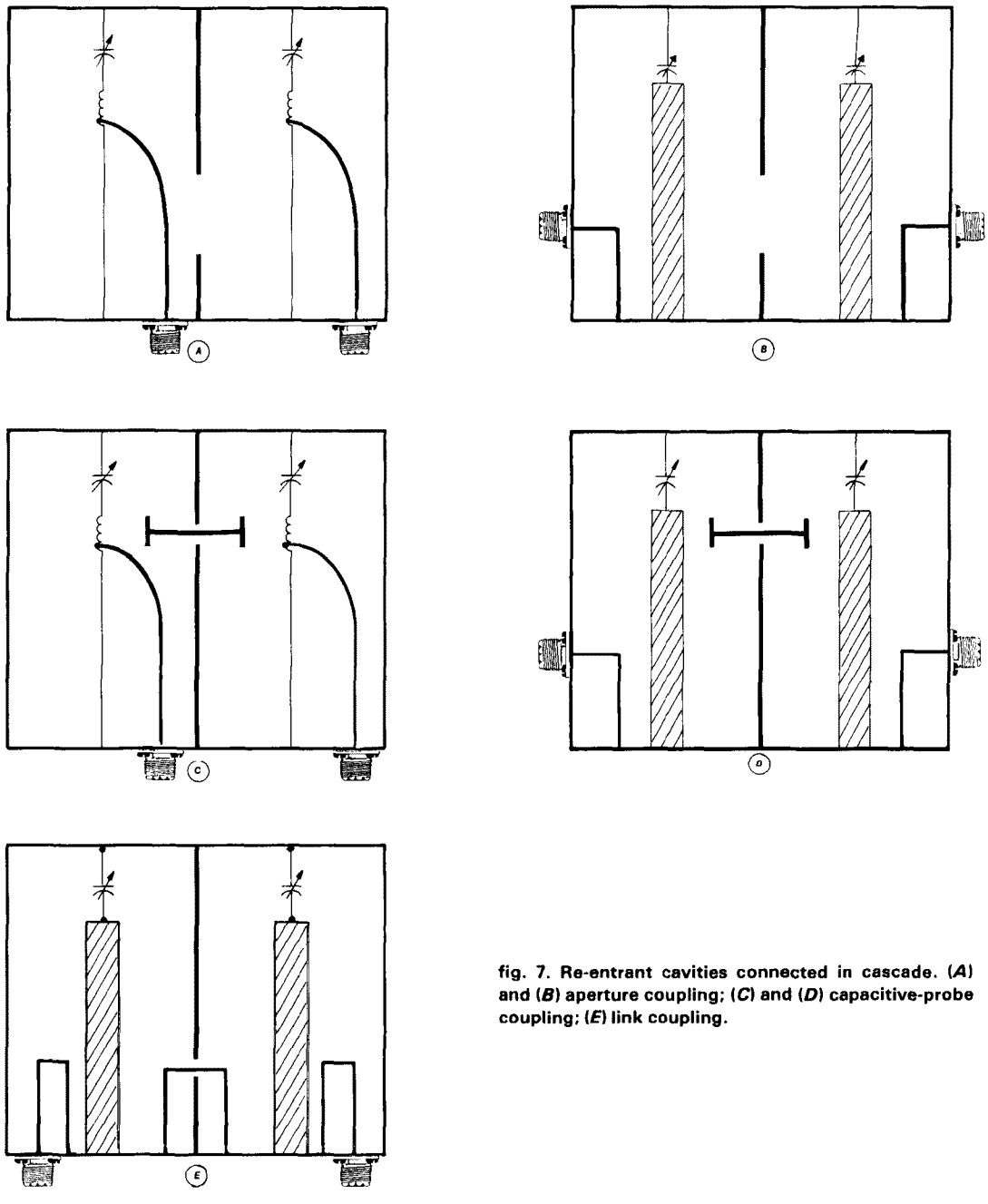


fig. 7. Re-entrant cavities connected in cascade. (*A*) and (*B*) aperture coupling; (*C*) and (*D*) capacitive-probe coupling; (*E*) link coupling.

circuited end of a resonant re-entrant cavity. Coupling is increased as the loop is positioned closer to the center conductor, as the enclosed area of the loop is increased, and as the plane of the loop is oriented to enclose a maximum of magnetic flux. The opposite of this action will reduce coupling. Capacitive probes are used to couple into and out of the electrostatic field, which exists at the open, high-impedance, end of the cavity. Coupling is increased as the probe is positioned closer to the center conductor.

Impedance matching. Impedance matching with loops isn't critical and is usually determined experimentally to obtain empirical guidelines inasmuch as the size, shape, and positioning will affect results. More precise design calculations are possible when direct connection is made to the center conductor when that method is called for. In most cases, an engineering compromise must be made in a particular application to obtain the desired selectivity, insertion loss, and impedance match.

Cascade coupling. Where more than one cavity is to be used in cascade, several coupling methods may be used, as shown in **fig. 7**. The degree of coupling is determined by the size of the window in aperture coupling, the interconnecting loops in loop coupling, and the proximity of the capacitive probes in capacitive coupling. In all cases, critical coupling will provide a greater usable bandwidth with steeper skirt selectivity, as shown in **fig. 8**.

The discussion above only scratches the surface with regard to resonant re-entrant cavity principles and practices. More detailed technical and construction information will be found in the literature listed in the bibliography.

a worthwhile project — basic cavity

For readers who wish to acquire a working acquaintance with re-entrant cavities, I strongly suggest the building of a simple, basic cavity. All that's required is a coffee can and a few parts usually found in the average junk box. Parts required are a 1- or 2-pound coffee can, a 50-pF variable air dielectric capacitor with a knob shaft, two coaxial-cable sockets, a center conductor made of copper or brass tubing anywhere from 1/4 to 1 inch (6.5-24.4 mm) OD, and a short length of No. 12 (2.1-mm) copper wire for the pickup loops.

Construction. Using **fig. 9** as a guide, make an opening in the center of the bottom of the can to provide a tight fit to the center conductor and solder securely in place. An alternative method is to solder the center conductor to a coax connector hood such as the UG-177/U or UG-106/U, then attach the assembly to the bottom plate with four machine screws and/or solder, **fig. 10**. Mount the variable capacitor close to the top of the can. Solder the stator to the center conductor using as short a lead as possible.

Make certain that the rotor wiper is clean. Ground it directly to the inside of the can. Mount the two sockets diametrically opposite each other about 3 inches (76 mm) above the base. Solder pickup loops

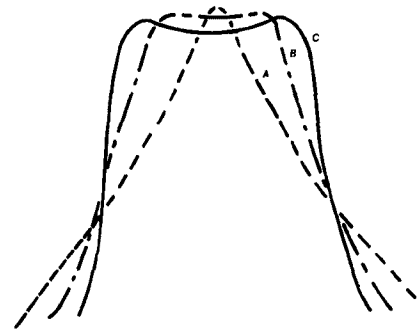


fig. 8. Relative selectivity curves. (*A*), undercoupled; (*B*), critical coupling; (*C*), over coupling.

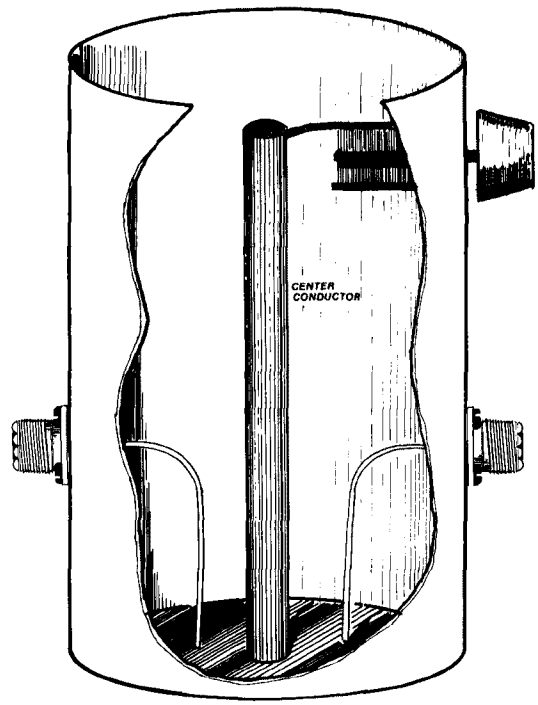


fig. 9. Cutaway of coffee-can resonant re-entrant cavity.

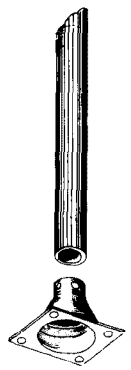


fig. 10. Alternative method of attaching center conductor to coffee can using UG-177/U or UG-106/U coax hood.

By experimenting with this simple re-entrant cavity, you should become familiar with its capabilities and also find it to be a useful piece of equipment in your 2-meter work.

five-eighth wavelength mobile whip antenna

For mobile operation in the 2-meter band, the 5/8-wavelength whip antenna has gained considerable popularity because of its widely publicized 3-dB gain over a 1/4-wave ground plane antenna. Gain figures for vertical antennas can be very confusing and not too meaningful unless referred to a particular vertical angle of radiation. For example, when compared with a 5/8-wavelength vertical, the 1/4-wavelength vertical may provide more gain at high angles and

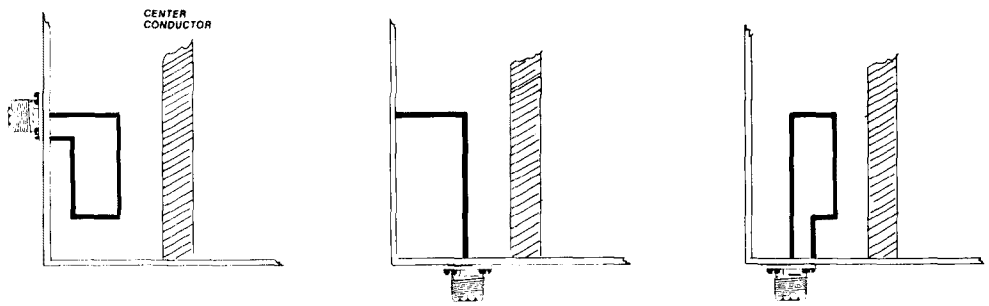


fig. 11. Other loop designs for coffee-can cavity.

as shown. Other loop configurations that can be used are shown in **fig. 11**.

Checkout. Insert the re-entrant cavity into the transmission line as shown in **fig. 12**. Select a weak signal in the 2-meter band and tune the variable capacitor for maximum response; don't be surprised at the very sharp tuning. On low-power transmit, readjust the capacitor slightly for the lowest SWR reading. Without disturbing the cavity tuning, change the transmit frequency about 1 MHz up, then down, and observe the change in SWR. This will give you a good idea of the selectivity of this re-entrant cavity. If you use a dummy-load and wattmeter instead of an antenna to make this test, you can correlate the SWR change with power-output change.

Try bending the pickup loops with long-nose pliers so that they extend closer to the center conductor. Your measurements should show a bandwidth increase, as evidenced by less change in SWR and power output as you repeat the first test. Then try bending the loops toward the housing; you should then notice a narrowing of the bandwidth, **fig. 13**.

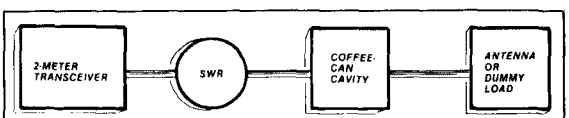


fig. 12. Test setup for coffee-can cavity.

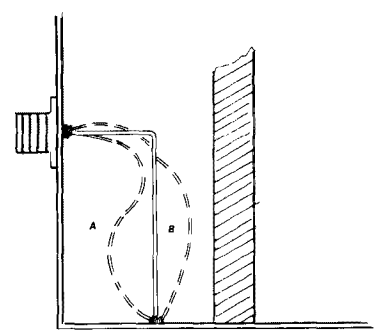


fig. 13. One method of increasing or decreasing coupling. Less coupling is at (*A*); more coupling is at (*B*).

less gain at very low angles. A direct comparison without reference to the vertical angle is like comparing apples to oranges.

In 2-meter mobile operation, where in most areas a low vertical radiation angle is highly beneficial, the 5/8-wavelength vertical outperforms the 1/4-wavelength vertical by about 3 dB. The chart in **fig. 14** shows a theoretical comparison between verticals of various lengths. An excellent discussion on this subject is presented by Lee[7] and Schultz.[8]

The 5/8-wavelength vertical antenna exhibits a radiation resistance of well under 100 ohms, which makes for convenient matching to a low-impedance transmission line, **fig. 15**. Because 5/8-wavelength is a nonresonant length, it appears highly capacitive in reactance (**fig. 16**) and requires the addition of sufficient inductive reactance to achieve resonance. As shown clearly in both **figs. 15** and **16**, the ratio of length to diameter, A/D, has a decided effect on the radiation resistance and reactance of a 5/8-wavelength vertical antenna.

Inductive reactance may be obtained for a 5/8-wavelength vertical antenna simply by using a small resonator coil at the antenna base. A section of coaxial cable, shorted at one end and less than a quarter-wavelength long, is equivalent to an inductive reactance and also can be used. Various combinations of coils, with or without capacitors, may be used to resonate a 5/8-wavelength whip antenna, as shown in **fig. 17**.

When measuring the length of a 5/8-wavelength vertical antenna, the physical length of the resonator assembly should be included unless it's shielded and at ground potential so that it doesn't radiate. (Note that there is a small insertion loss in the use of any type of resonator.)

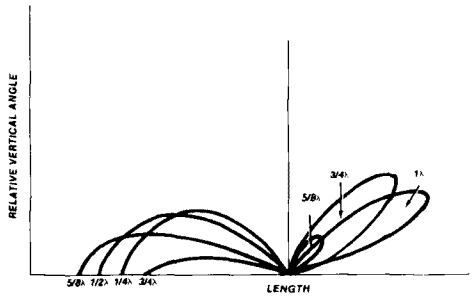


fig. 14. Vertical-angle patterns of various lengths of vertical radiators. Five-eighths wavelength, three-quarter wavelength, and full wavelength high-angle lobes are shown on right for clarity. (Note absence of low-angle lobe for full-wavelength vertical.)

resonant re-entrant cavity whip antenna*

The resonant re-entrant cavity whip antenna evolved as the result of an attempt to provide a means of eliminating the chronic interference problem that plagues 2-meter operation throughout the "intermod alleys" of our country.

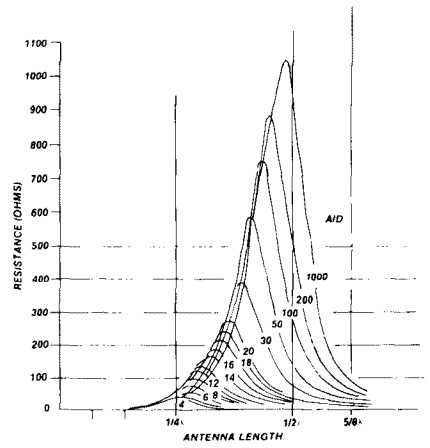


fig. 15. Terminal resistance as a function of antenna length. A/D is the ratio of antenna length to diameter.[10]

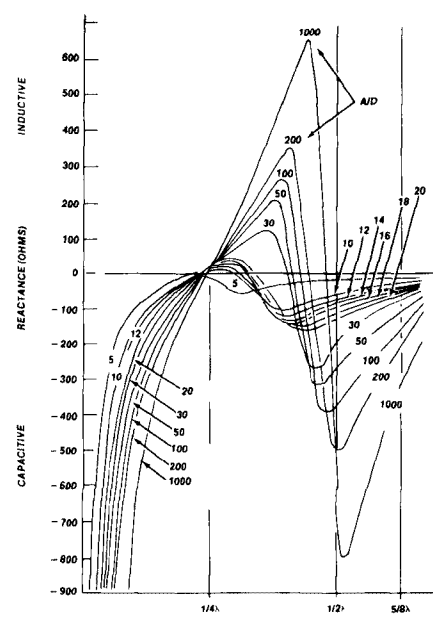
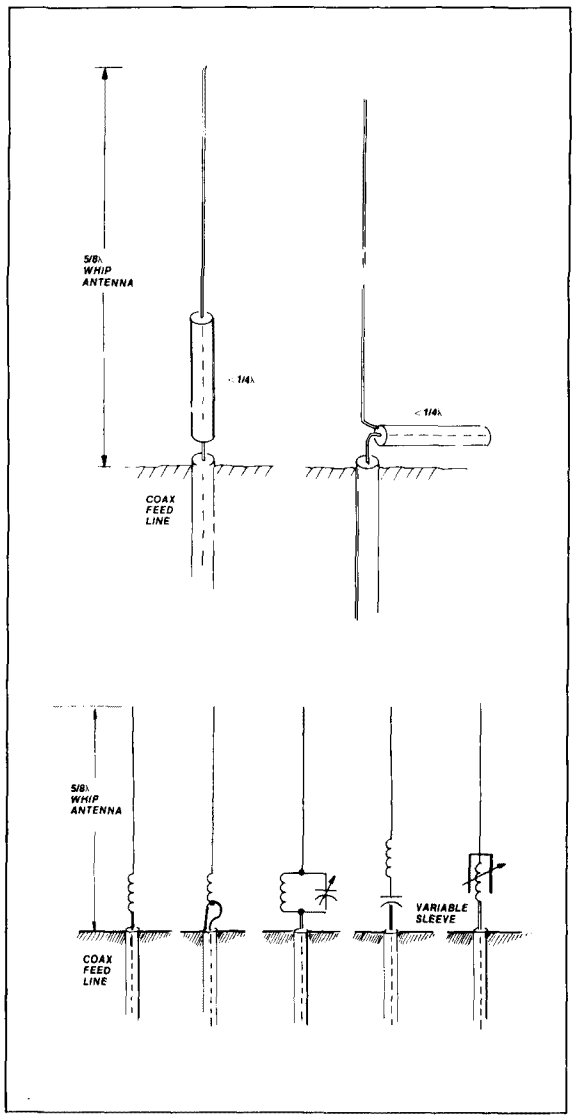


fig. 16. Terminal reactance as a function of antenna length. A/D is the length/diameter ratio.[10]

*U.S. Patent 4,128,840.



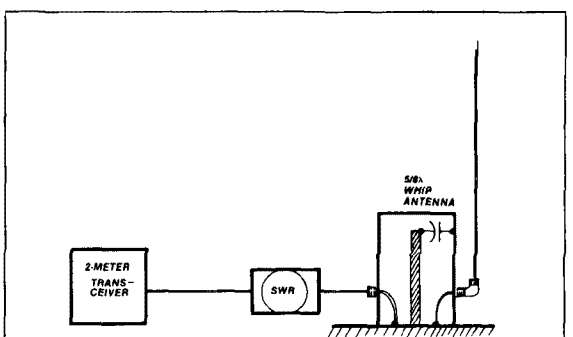


fig. 18. Coffee-can resonant re-entrant cavity used as a resonator for a 5/8-wavelength vertical. Pickup loops are adjusted for lowest SWR at resonance.

A re-entrant cavity is used to replace the usual base resonator used in the 5/8-wavelength whip antenna to provide much-needed bandpass filtering right at the antenna itself where it is most effective. In this manner, unwanted out-of-band signals will be attenuated before they enter the transmission line and ultimately reach a vulnerable receiver front-end.

At this point, you might question the need for this type of antenna for use with your latest-model transceiver with built-in helical resonators. The answer is self-evident in the fact that the proximity of these resonators to the receiver front end on the PC board still allows very strong unwanted signals to leak through and excite highly sensitive circuitry. Also, in many cases, due to space limitation and cost considerations, engineering compromises result in barely adequate helical resonator assemblies. Therefore, the use of this type of antenna will provide the additional bandpass filtering needed to enhance the ability of the receiver to reject unwanted signals.
receiver to reject unwanted signals.

Of course, in transceivers that don't have built-in helical resonators, the use of this type of antenna will be dramatically effective. In either case, because this antenna will be used in transmit as well as receive mode, bandpass filtering will attenuate spurious emissions, re-radiated intermod, and white noise.

As in all resonators, the re-entrant cavity used in

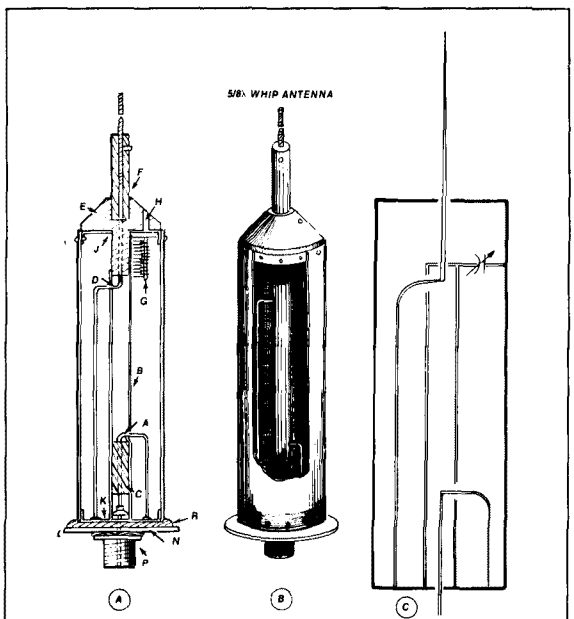


fig. 19. Five-eighths wavelength resonant re-entrant cavity whip antenna in cross section (*A*), cutaway (*B*), and schematic diagram (*C*).

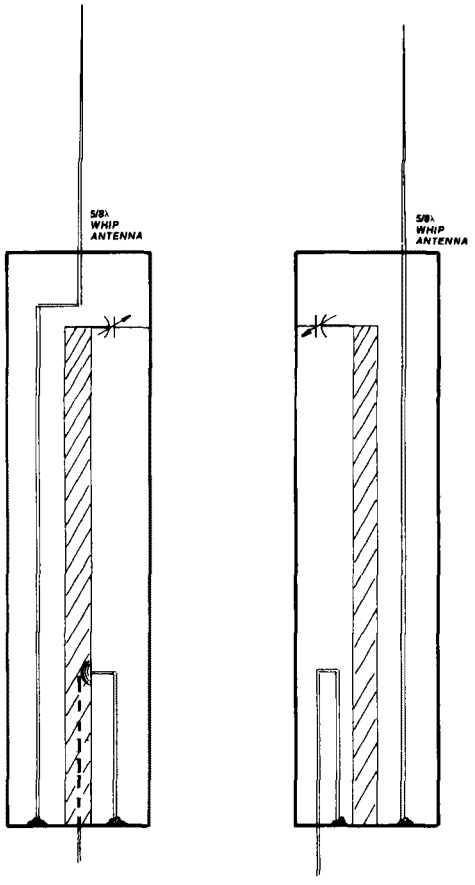
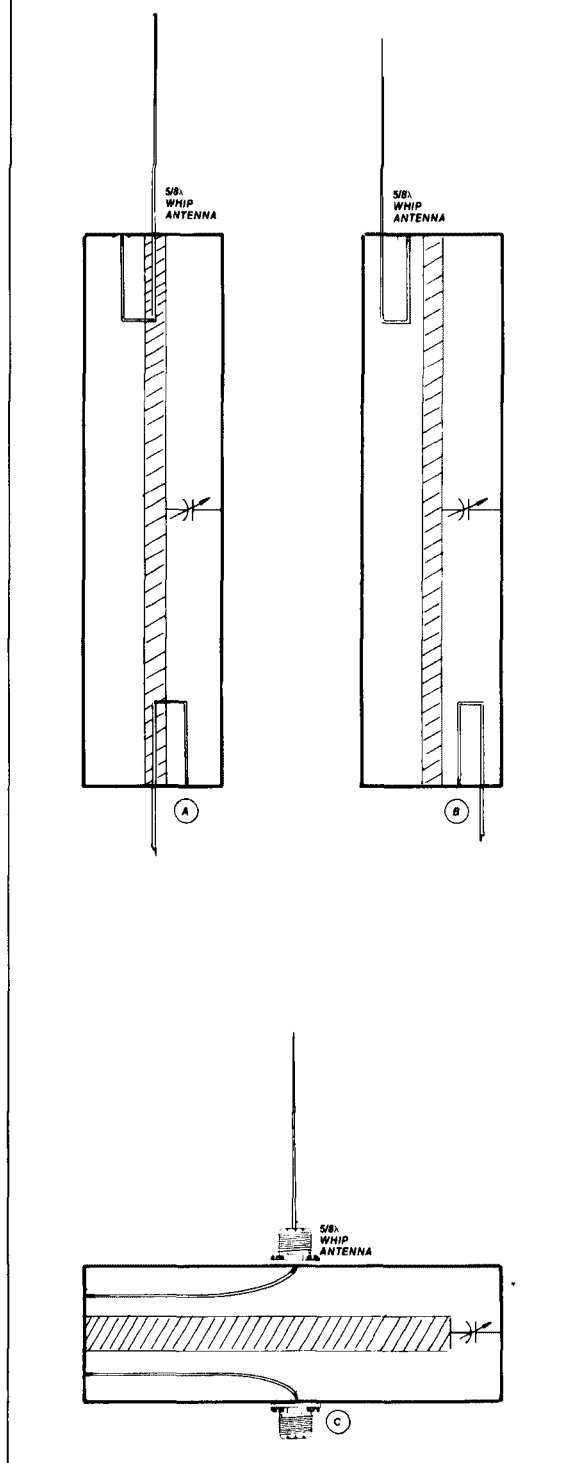


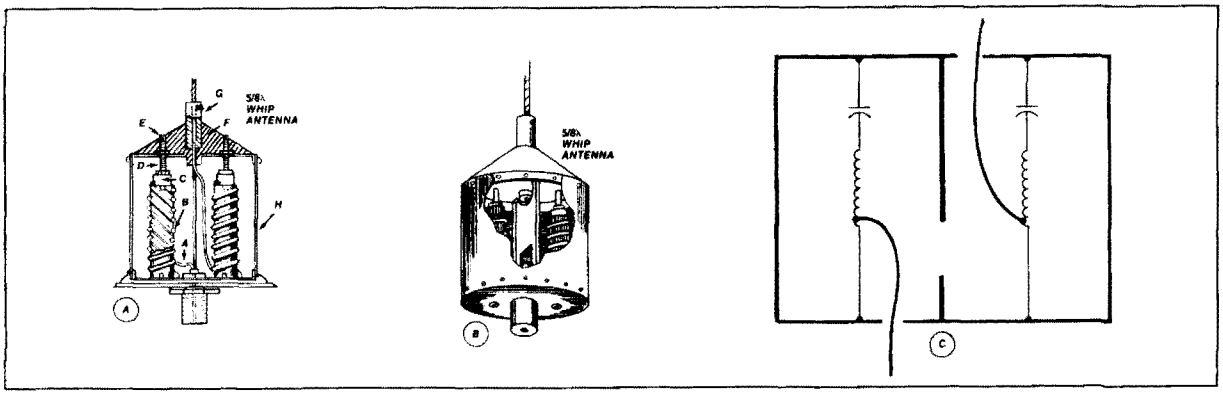
fig. 20. Example of other workable re-entrant cavity designs.



this antenna has a small insertion loss at resonance, which is about the same as the loss in the usual resonator that it replaces. However, there are bandwidth limitations under certain conditions which will be discussed later.

Coffee-can cavity. For those who wish to do a little experimental work to get the *feel* of this type of antenna, it's a simple matter to attach a 5/8-wavelength whip (about 48 inches or 122 cm) to a coffee-can type of re-entrant cavity as shown in **fig. 18**.

Construction and adjustment. Two strips of aluminum foil 45 inches (114 cm) long and about 4-5 inches (10-13 cm) wide placed under the can and grounded to it on any flat surface will provide an adequate ground plane. With an SWR meter in the feedline, tune the cavity for the lowest reading, which



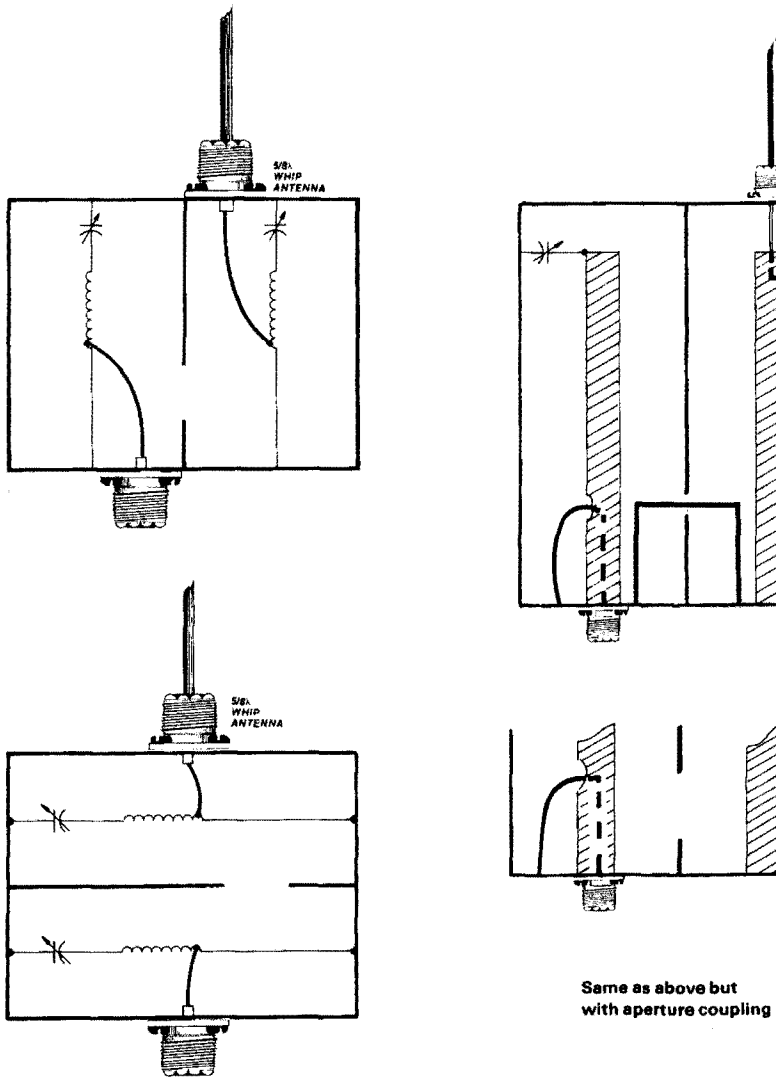


fig. 23. Other workable 2-meter 5/8-wavelength resonant re-entrant cavity whip antennas using cascaded cavity resonators.

may be too high. Adjust the antenna feed pickup loop until the SWR is very low at resonance; the whip has now been resonated. The input loop may now be repositioned and reshaped for the desired degree of selectivity versus insertion loss. Keep in mind that all adjustments are interdependent.

Fig. 19 shows two views and a schematic diagram of a resonant re-entrant cavity whip antenna in a more sophisticated configuration that has an external appearance similar to that of the usual 5/8-wavelength whip antenna. The cavity section is about 7 inches (18 cm) long and 1 1/2 inches (3.8 cm) in diameter.

To provide this concentric configuration, the input pickup loop, A, is fed through an opening in the center conductor, B. The insulation, C, and the lead wire passing through it actually extend the coaxial cable feedline to the loop opening. The antenna pickup loop, D, enters an opening very close to the top of the center conductor and feeds through the Teflon insulator, E, to the set screw adapter, F. The cavity is tuned to resonance by the variable air-dielectric capacitor, G, with a screwdriver adjustment at H.

The entire interior assembly is self-supporting and is held together by center conductor B, insulator E, top plate J, bottom plate K, and the variable capacitor, G. This allows the outer conductor to be removed for internal adjustments.

This antenna may be installed and grounded to the vehicle, N, using the coaxial connector, P, and its nut and lockwasher. The rubber gasket, R, provides a weatherproof seal to the vehicle body.

This model is just one example of how a 5/8-wavelength resonant re-entrant cavity antenna can be built. A sampling of other workable configurations in semi-schematic form for the 2-meter band is shown in **fig. 20**. Additional configurations, which are practical only for the higher-frequency bands, are shown

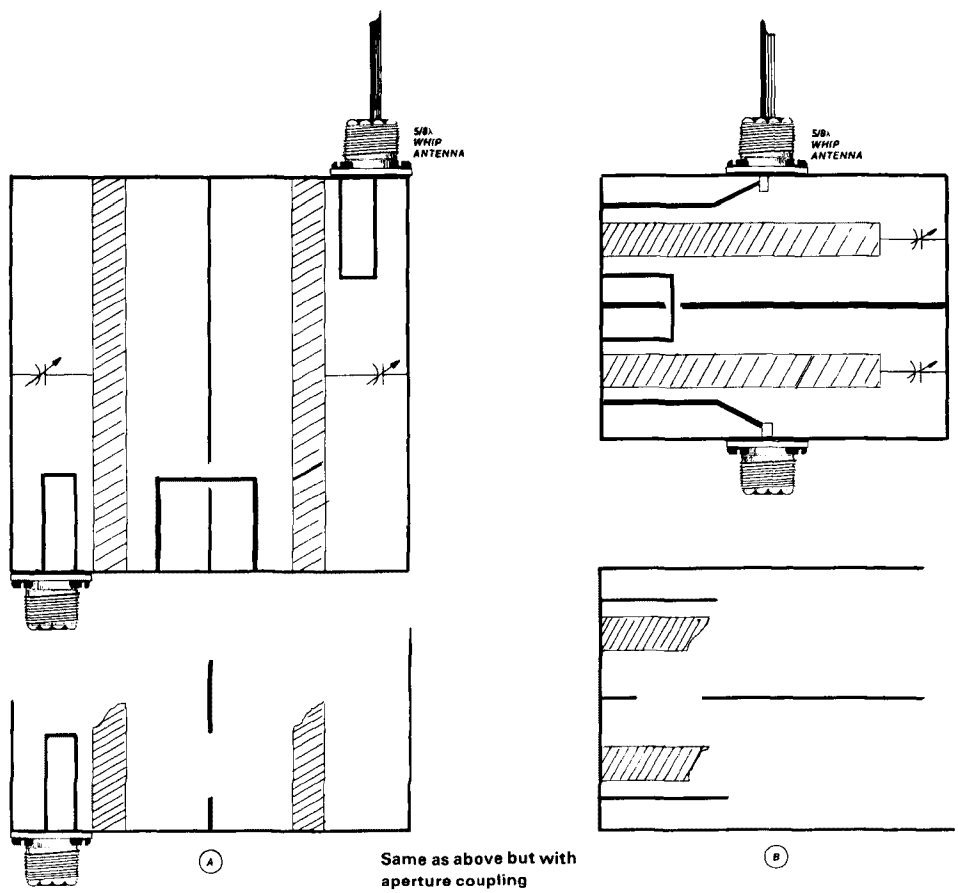


fig. 24. Designs for use on 220 MHz and higher bands. One-half wavelength resonant re-entrant cascaded cavities are shown in (*A*). One-quarter wavelength cascaded cavities are shown in (*B*).

in fig. 21.

Unfortunately, to obtain fairly high rejection of out-of-band signals 3-6 MHz away in frequency, such as encountered with interference from the 150-170 MHz commercial band, the usable bandwidth of a single-section cavity antenna is limited to less than 1 MHz. By using very tight coupling, the bandwidth can be increased considerably but at the expense of selectivity. Where the interference is from fm and TV broadcast stations, tight coupling will still provide sufficient selectivity. The solution to this problem is to use two re-entrant cavities fed in cascade which will, when critically coupled, provide a wider bandwidth with steeper selectivity skirts, as previously discussed.

another model — the helical resonator

Fig. 22 shows two views and a schematic diagram of a resonant re-entrant cavity whip antenna using two helical resonators aperture-coupled to each other. The input coaxial cable is fed to a low-impedance tap, A, on the input coil, B. This coil is tuned to resonance by a variable piston-type capacitor formed by C and piston D and is tuned by screwdriver adjustment, E. The tap on the antenna coil is fed through the Teflon insulator, F, and is attached to the set-screw whip adapter, G. The aperture in the center-shield partition provides the magnetic coupling between the resonators.

The entire assembly is self-supporting so that the outer conductor, H, can be removed for adjustment. This antenna may be installed and grounded to the vehicle in the same manner as the antenna previously described.

With the helical resonator, the aperture size is increased experimentally until critical coupling is noted by increased bandwidth and steeper selectivity skirts. The taps on the coil are determined to match the coaxial-cable impedance to that of the antenna. Tuning adjustment of the antenna coil will automatically resonate the 5/8-wavelength whip section. As in the other model, the resonator is tuned for minimum SWR.

This cascaded model is just one example of a dual-cavity whip antenna. **Fig. 23** shows other workable configurations for the 2-meter band, and **fig. 24** shows additional models for the higher-frequency bands.

microstripline antenna

A 5/8-wavelength whip antenna can also be built using another hybrid variety of the re-entrant cavity known as the microstripline, which consists of a two-sided PC board etched on one side only.

One side is the groundplane, and the other side is etched into strips, as shown in **fig. 25**. In this dual-section design, coupling is usually accomplished between sections at the high-impedance end with a small variable trimmer capacitor. The Q of this type of resonator is less than that of a helical resonator and has more restrictive power-handling capabilities. However, it should provide some interesting possibilities for the experimenter. The late Jim Fisk wrote a comprehensive article on microstripline design in 1978.[9] Also several articles by Shuch[10, 11, 12] in recent years cover the subject quite well.

conclusion

The resonant re-entrant cavity whip antenna, within its limitations, would provide Amateur Radio experimenters with a lot of new territory. I welcome comments from those who delve into it.

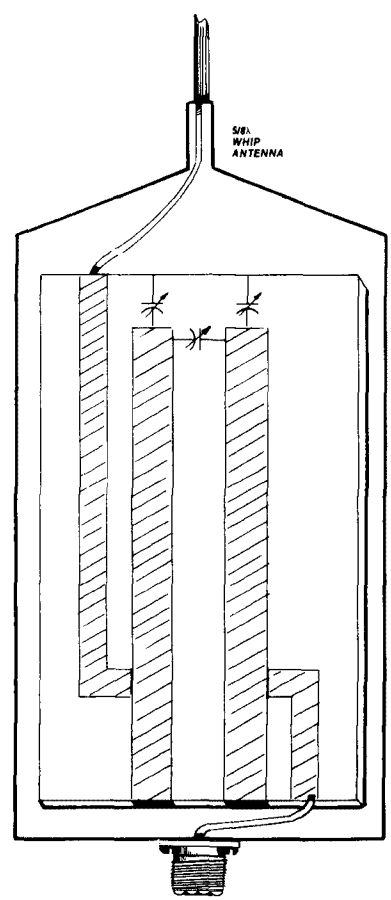


fig. 25. Resonant re-entrant cavity 5/8-wavelength whip antenna using microstrip techniques.

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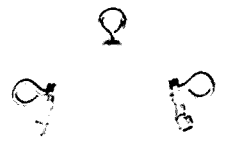
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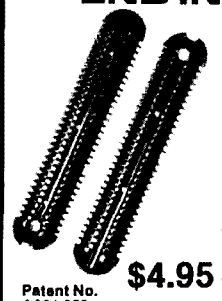
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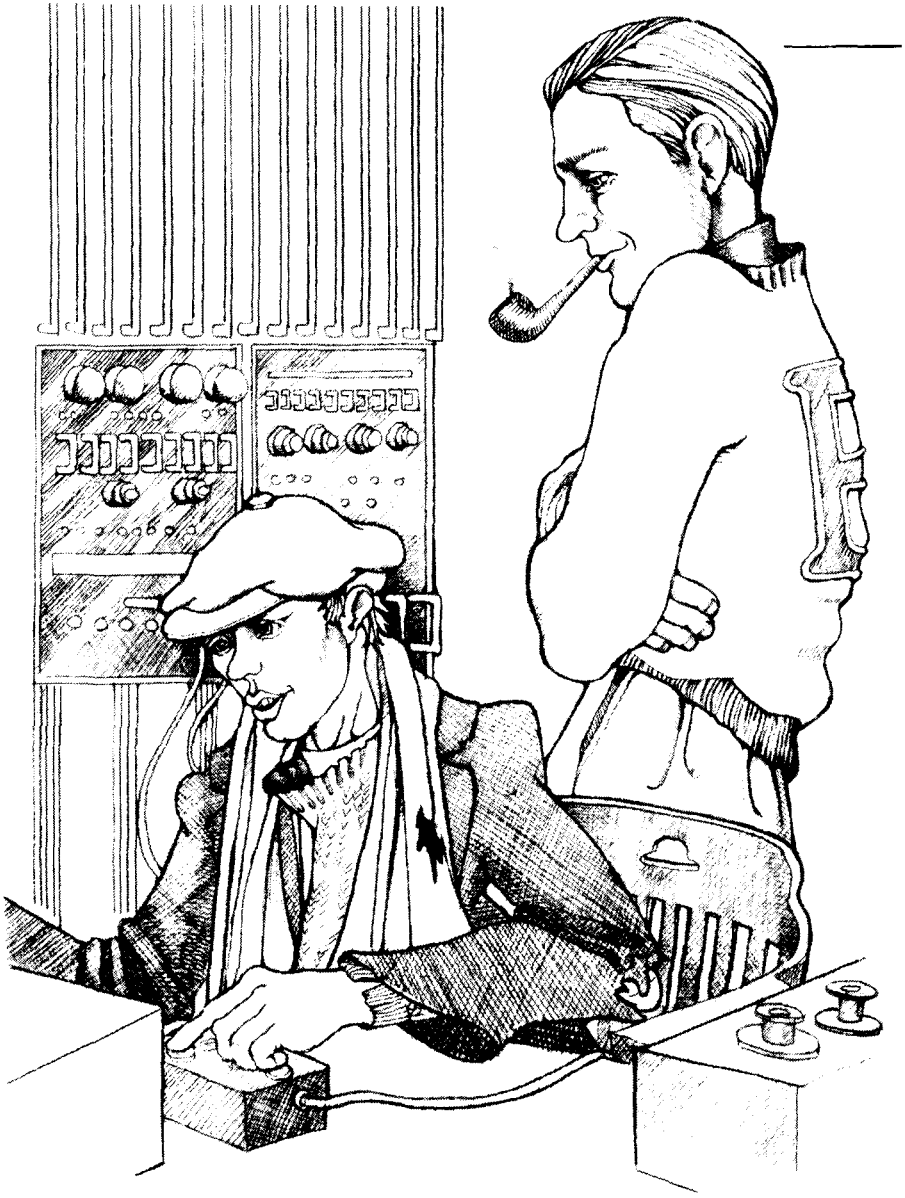
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Jim

A Tug at Your Memory

By John C. Flippin, W4VT*

It was 1935 and the Great Depression was upon the land: people out of work, no money to pay the grocer, lines of men outside the Salvation Army building waiting for a cup of soup, men on street corners selling apples for a nickel. Walking down the boulevard, one was approached by ragged-looking souls, always with the same question: "Brother, can you spare a dime?" Yes, the country had fallen onto bad times. But, paradoxically, Amateur Radio grew at a phenomenal rate during this era. Perhaps the following story might contain a clue. Thanks to Laird Campbell of *QST* for allowing us to reprint the story of *Jim*. **Editor**



The fire in the shack of the university radio station burned low and conversation lagged. Every now and then someone yawned lustily. The hands of the old clock pointed to five minutes after two, yet half a dozen seniors lingered, for the fire was magnetic, the walk back to the dormitory and fraternity houses long; and the night was cold. Lazy, feathery flakes, beginning to drift down at midnight, had changed to a fine, peppery mist swirling in from the north, and the wind moaned down the chimney in icy cadences.

Jug Southgate stood up and stretched.

"See you mugs in church," he grunted, looking around for his overcoat.

"Wait a minute. I will let you walk with me. Hey! get your big feet off me!"

"Freshman, where are the earmuffs?"

"Right here, sir."

"Put them on at once. Anybody would think you had no modesty at all."

"Get up! Get up!"

"Coming, Ivy?"

"Let's go."

Exiled in a shadowy corner, a group of freshmen had been listening in respectful silence. Now they rose, after a discreet interval, and removing their sky blue caps from their hip pockets placed them carefully on the backs of their heads. Beside them stood a little fellow who was busily engaged in wrapping a rather frayed scarf around his small neck. Judging from his stature he could not have been much older than fourteen, and he looked very small and out of place beside them. The shadows from the fire treated mercifully the worn places on the elbows of the coat which was so obviously designed for a larger occupant; they shielded understandingly the worn, cracked shoes with the scuffed toes.

His name was Jim. Nobody knew much about him except that he lived up in town some where, and that every Saturday night he appeared at the shack, slipping quietly into a seat amid the shadows in the corner, and listened with rapt attention to every word that anyone uttered. He always stayed until the group of fellows broke up. Jim replied feebly and shyly to those who would talk to him,

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apparently embarrassed at the attention. His face and hands were very thin and his eyes were very bright. He was a small outsider looking in on a gathering with which he could join only in spirit. College would never be for Jim.

The wind whined savagely. A flurry of snow beat a faint tattoo on the window.

"Ouch!" muttered Ivy. "Listen to that!"

Jug cast his gaze around as he pulled on his gloves. The staccato clatter of the keying relay in the adjoining room reminded him to caution Parkes about playing the end of the band too closely since the multivibrator was down for revamping. Turning back, his glance rested for an instant on Jim stretching his hands out to give them a last warming. Something about the little fellow's appearance arrested Jug's attention. Maybe it was the tattered edge of that scarf about Jim's ears.

"What do you say over there, sport?"

Jim didn't notice.

"You over there by the fire! Got a way to get in?"

Jim looked up, and saw Jug looking at him. He straightened up quickly and thrust his hands into his coat pockets.

"Sir?"

"Got a ride into town with somebody?"

"No."

"What are you going to do — walk?"

"Yes," answered Jim.

"Pretty long way, isn't it?"

A pause.

"Not so much."

Jug embarrassed Jim a great deal, because Jug was the chief operator and wore sterling crossed bars of chain lightning on the shoulder of the navy blue jersey. There was no greater this side of Heaven, save perhaps the three comprising the transmitting staff.

Jug shoved his pipe in his mouth and turned the bowl down. He squinted up at the clock.

"Hold on, frosh!"

He pulled off his gloves and searched in his hip pocket, producing nothing but a handkerchief and a crumpled pack of cigarettes.

"Can't find 'em. Listen! You know where the Sigma House is? OK — you go over there and look around in the back. My iron ought to be there, but if it isn't, get any of them that will start. You know mine?"

"Yes, sir."

"Look around in the front seat and find you a hairpin or something and short around the switch under the dash. You know?"

"Yes, sir."

"And hurry up, frosh!"

Rather bewildered, Jim listened.

"I can get there all right," he said finally.

Jug grunted and sat down.

"Where do you live in town?"

"Er — down by the depot. The third house from the corner."

"Guess you know all the trains."

"I guess so. The freights make an awful lot of QRM when I'm trying to listen."

Jug stuffed his pipe slowly and extracted an ember from the hearth.

"You one of these amateurs, too?"

"Yes, that is — I mean, I have a station, but it's not much good, I guess."

A flicker of surprise crossed Jug's persistently sunburned countenance.

"Didn't know there was another station within fifty miles of here," he admitted. "What do you use? Never heard you."

"A 201-A," answered Jim.

The rectifiers down below howled faintly.

"Any DX?" asked Jug, quizzically, glancing at the little chap out of the corner of his eye.

"No, I — you see, I never worked anybody."

"What's the trouble?"

Jim stopped the nervous movements of his small hands and wiggled his thumb, just to see if it would wiggle.

"I don't know."

"Just don't come back, eh?"

"No."

"Call many of them?"

"Yes, I — well, I call a lot of fives and nines and fours."

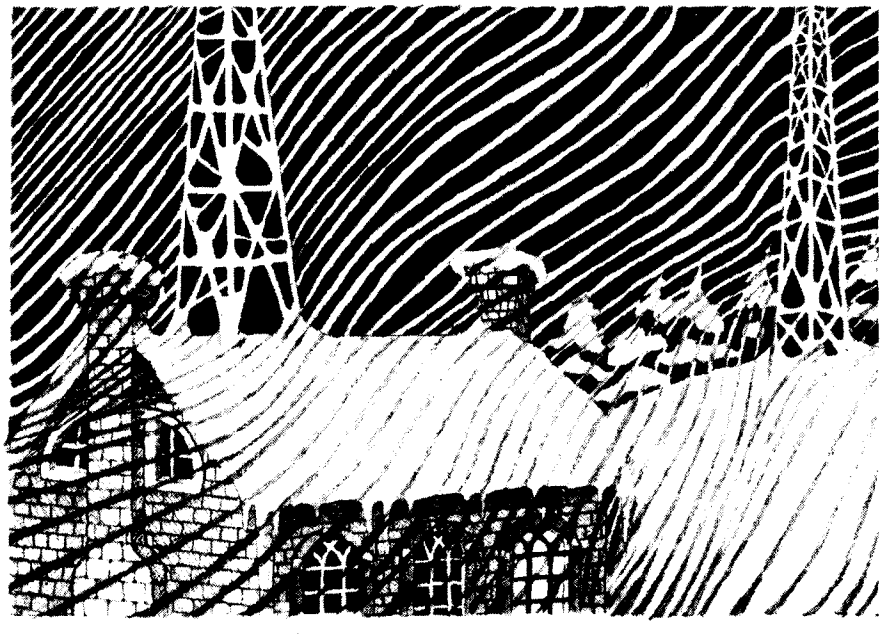
"Sure you're in the band?"

"Yes."

"How do you know?"

"I cover up my receiver with a cracker box and then I can hear the transmitter. After I take off my receiving aerial," he added.

Jug looked at Jim for an instant, and then gazed again into the fire. There was a pause while Jim twisted



his small, thin hands nervously.

"I know it's putting out," said Jim, faintly, "because I get a burn."

"Burn, eh?"

"Yes."

"Just don't come back."

"No."

The pity of it.

"Much of a burn?"

"Well, I can feel it on the back of my finger." Jim held up the radio frequency detector.

"How long have you been trying to raise them?"

"Since about May — I mean, April."

"Nine months."

"Yes," answered Jim, after a pause.

Jug exhaled a cloud of smoke through his nose and regarded the fire. Some game, this! Nine months and never a break.

There was a dull rattle of contactors down below, followed by a volley of clicks in the adjoining room.

"What made that?"

"Sounds like he switched in the '7' — the forty-meter rig."

"You mean he's using another set, now?"

"Just the amplifier. Switched over the exciter from the 80-meter to the 40-meter amplifier."

"Oh!"

"Sit down! Sit down! Make yourself comfortable. Guess it'll be about fifteen minutes, yet."

Jim slid cautiously into the nearest chair. Suddenly he turned and regarded Jug inquiringly.

"Would you mind — I mean, would it be all right if I looked in there?" he asked, pointing to the transmitter room.

"Sure! Go ahead. Help yourself. Wouldn't get too close, though, to the one nearest this side."

Jim opened the door cautiously and craned his small neck. He stood transfixed for long minutes.

"Gee!" he whispered.

"Look all right?" Jug asked, pulling his pipe apart and blowing through it with two short snorts.

"Gee!" said Jim again.

Five minutes passed with only the wind, the old clock, and the keying relay breaking the silence.

Jug looked at the swirl of smoke ascending the broad black throat of the chimney, and his thoughts travelled back to a day — so long ago, it seemed — when that UV-202, its plate glowing brightly, brought the antenna ammeter to life. As he recalled, the pointer moved over about a thirty-second of an inch, but at the time, it looked like a foot!

And then that red-letter day. He had just called CQ. It was just one of many scores of CQ's. There was nothing to distinguish it from all the others except that on this occasion 9EKY in St. Louis came back. The wild shout that brought the gardener, the chauffeur, and both maids breathless to the sanctum over the garage was not, as they feared, Mr. Edward Southgate III getting a mortal shock from his peculiar conglomeration of wires and sparkling Mason fruit jars, but merely the result of Mrs. Southgate's youngest son making contact number one with his trusty bottle!

Jug looked at Jim standing in the door. The frayed scarf. The worn old overcoat hanging awkwardly from his small body.

"Know the code pretty well?" Jug asked, rising slowly, and returning the tobacco pouch to his pocket.

"Sir?"

"Can you copy pretty well?"

"Yes — well, I guess I can copy ten words a minute, I guess."

"Want to go upstairs?"

"Upstairs?"

"Want to see the operating room?"

"Oh! Yes!"

Jug led the way with Jim following at his heels. A series of coughs escaped Jim at the top of the flight, and alarm possessed him that he would disturb the operator. He tiptoed in behind Jug, his small face radiant with excited expectation.

"What say, Jug?"

"'Lo, Bohunk. How goes it?"

"Fair."

"Where you working now?"

"Using 7005. Don't worry, it's inside."

"Did you check it with the oven?"

"Yes, it's right on the line."

Jim was all eyes. He looked at the Single-Signal receiver, at the typewriter, at the 100-kc. secondary frequency standard, at the steel front control panel alongside the operating desk. The shiny brass handwheel on it. The meters. All the relays in the back. The lacing on the cable runs. Resistors standing upright in groups. Jim's excited inspection saw it all!

"Anything coming through?"

"Few. Good many VK's and ZL's. Heard J2GX a minute ago. May be pretty fair later on."

Jug rested his elbows on the operating table and said something to Collier Parkes. Jim didn't hear. Jim was busy. He was looking intently at a Kleinschmidt perforator partially disassembled, wondering what manner of thing it was.

Parkes grinned.

"Sure! Sure!"

Jug's voice dropped lower.

"No," said Collier, "I got one with K6BAZ in fifteen minutes. Plenty of time for that, though. You go ahead while I go out here and look up another pad of message blanks — or something," he added.

He disappeared, clattering down the stairs.

"Want to listen in?" Jug asked, motioning to the receiver.

Jim came over to the operating desk and looked at Jug, then looked at the receiver. A great fear came over him. It was too beautiful to get close to; the baffling controls marked "R.F. Gain," "Selectivity," "A V C" "Voice — C.W.," and "Crystal Filter" were formidable. It was only to be looked upon from a distance.

Jug pulled the swivel chair up with his foot.

"Sit down. Sit down."

Jim let himself down slowly and looked around at the control panel. His elbow touched the shiny handwheel, and he hastily pulled it back, and then let it slide down again. This

was real. It was not a dream.

Jug tripped one of the switches up with his thumb and motioned to the knob in the center.

"Turn that one."

Jim looked up at him inquiringly and touched the knob timidly. The shadow scale above it moved slightly. How easily it turned! Encouraged, he moved it a little more. A faint hiss which had begun to evidence itself in the dynamic speaker was at that instant ripped asunder by a kaleidoscope of crisp, bell-like signals which caused the moving coil of the speaker to wiggle perceptibly. Jim looked at it quickly. The sound seemed to hit him in the stomach, like when the bass drum passed in a parade. Just listen! A procession of grunts, drones and crystal ringing notes shrilled slowly by.

"Slow! Slow! Back this way."

Jim turned the knob back. Gee! It turned so easily, just seemed to glide! Entranced, he watched the shadowy divisions and numbers slip across the sloping, ground glass window. Was this real? His elbow slid back against the handwheel inquiringly. Yes, it was real, all right.

Slowly the dial moved back toward the 7000-kc. end. The terrific honk of W6's tore through. A myriad of faint signals in between that a touch of Jug's finger on the gain transformed into ear-splitting intensity.

"Whoa!"

A faint lisping note. Jug brought it up to a good level. It seemed to stand out on top of all the rest, miraculously. The lisp increased in intensity. It signed.

"Hear that?"

Jim nodded.

"Japanese."

Jim's heart skipped a beat.

"Go on."

The dial crept back up the scale. A terrific shot of 100-cycle r.a.c. A fluttering rattle.

"Alaskan."

A hollow ringing crystal note with a peculiar wavering undertone.

"Get this one."

It was a long, slow CQ DX.

Jim's hands were trembling.

"KA1HR. Get it?"

Jim nodded.

"Philippines."

Jim's trembling increased.

The signal faded in slowly, dying away into the background roar, returning.

Jim's heart was pounding so hard it shook him.

"Calling DX."

Thousands of miles of black, tumbling ocean intervened. Outside, the two great towers, outlined irregularly in white, rose up and up into the swirling snow; downstairs the input reactors sang monotonously in the ghastly glow of the rectifiers. The filaments of the push-pull stage in the 7-mc. amplifier imparted a dull radiance to the polished edges of the neutralizing condenser discs. All were waiting, ready to hurl the dynamite.

"AR," grunted Jug, and with his thumb tripped a breaker closing switch at Jim's side. "OK! Go after him! Use the straight key over there."

Little Jim was shaking noticeably. He reached hesitantly over the battery of Vibroplexes strewn before him and grasped the key knob. He felt paralyzed. An hour seemed to pass. Suddenly the knob gave. Awkwardly he sent "KA" and stopped.

"What was his call again? Oh, yes — er..."

He began to call slowly and erratically. After a little he steadied a bit, but his heart was pounding so hard he couldn't control his arm. He was trembling as with a chill.

Downstairs, the pair of 204-A's, no respecters of persons, fired skyward all the savage energy that 4400 volts could impart. At every closure of the relay, the burnished plates of the tank condenser paled fitfully in the semi-darkness.

"Give him a long buzz."

Jim heard, but couldn't obey. The strength was gone out of him. Suddenly he found himself signing. He signed twice. K.

"Boy, you sure must believe in this signal all right," grunted Jug, tripping the breaker release.

For an instant only the background roar. Then the wavering drone started up.

Calling them.

"Well, what do you say now?" muttered Jug, glancing quizzically at Jim.

He didn't answer for a moment. Two large drops deposited themselves suddenly upon the log.

A faint sob came from the little fellow.

"I worked somebody," whispered little Jim.



butterfly beam

This interesting little 15-meter antenna, which is called the butterfly beam, is small, light, and easily made from ordinary hardware store materials. It's also inexpensive. The butterfly beam weighs less than 10 pounds (4.5 kg), it's less than 12 feet (4 meters) square, and cost me less than $20 to build. But despite its small size and low cost, this antenna has given me excellent results on both CW and SSB.

The heart of my butterfly beam is the Lexan spider hub sold by Van Gorden Engineering, P.O. Box 21305, So. Euclid, Ohio 44121. The hub is solidly put together and rugged, and the first time I saw one I thought: *antenna*. The central hole is perfect for the supporting mast. Tubing can be easily attached, and there's even a molded-in socket suitable for an SO-239 chassis connector.

construction details

Four 8-foot (2½-meter) lengths of 1-inch (25.4 mm) diameter aluminum tubing are needed, along with a 50-foot (15-meter) roll of soft aluminum ground wire and four 1-inch (25.4 mm) hose clamps.

It was necessary for me first to calculate the appropriate lengths for the wire elements, based on the 8-foot (2½-meter) tubing I intended using to build the X frame. Not having a capacitor for tuning the director, I reasoned that a close-enough approximation to the desired lengths could be made on a cut-and-try basis, using the starting points calculated (see **table 1**). **Figs. 1** and 2 show the schematic and general arrangement.

I used some light nylon line to tie the ends of the wire together. It's a good insulating material, and also offers the springy support needed to put the elements under slight tension. The socket connector bolts right into the spider hub, and an extra pair of

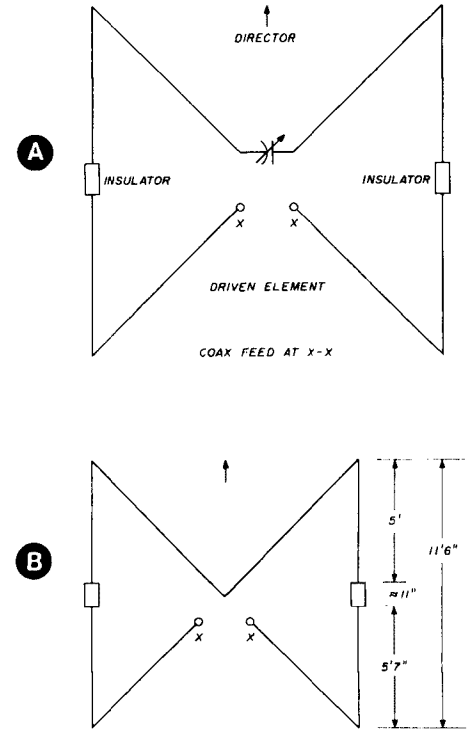


fig. 1. Schematic representation of the "butterfly" beam (A) showing the 'M'-shaped director, tuned by a capacitor, and the 'W'-shaped driven element with feedpoints X-X. It looks a bit like a quad loop, but lies flat instead of standing vertical. B shows dimensions of typical 15-meter version, constructed for lower band edge (21.0 MHz). In this figure, capacitor has been eliminated (see text).

By James Gray, W1XU, 28 East Street, Peterborough, New Hampshire 03458

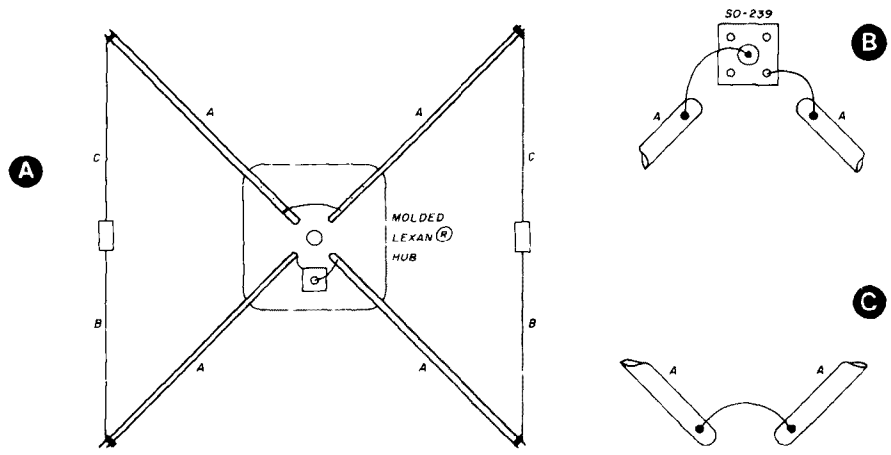


fig. 2. General arrangement of the "butterfly" beam as constructed by the author (A). B shows the SO-239 chassis connector with a wire from the center terminal to one leg of the driven element, and a wire from the shell to the other leg of the driven element. Make the connecting wires short, and use self-tapping screws and radio hardware. Solder connections, where possible. C shows bridge of wire between legs of the director. Variable capacitor could be substituted at this point (see text). Special molded hub available from Van Gorden Engineering (see text).

hose clamps can be used to couple the hub to the mast.

I used a short length of wire to bridge the inner ends of the director element. It's possible to use a tunable capacitor here, the rotor affixed to one leg of the director and stator to the other, because the Lexan hub makes a good insulator. Variable capacitor values would be 250 pF (for 20 meters); 175 pF (for 15 meters); and 125 pF (for 10 meters).

The overall size of each side of the antenna is approximately 11 feet 6 inches (3½ meters) on 15 meters, 17 feet (5 meters) on 20 meters, and 8 feet 6 inches (2½ meters) on 10 meters. The feed point is connected to the SO-239 chassis connector by means of some lengths of copper wire, the center terminal to one leg of the driven element and the ground, or surrounding part of the connector, to the other. The coax is attached to the connector and then waterproofed with a liberal coating of bathtub caulk.* A quarter-wave matching section is shown in fig. 3.

When mounting the butterfly beam on its mast, remember that the side wires, not the X-frame tubing, should be aligned with the direction of fire. The proper direction is a bisector of each X angle at the hub.

SWR has been 1.5:1 or less across the 15-meter band, and I've received excellent reports from all sorts of DX, both CW and SSB. When compared with my 14AVQ on the same signals, the butterfly has resulted in a reported average improvement of two S-units, with some reports running as high as 3. Assuming 3.33 dB per S-unit, my butterfly beam

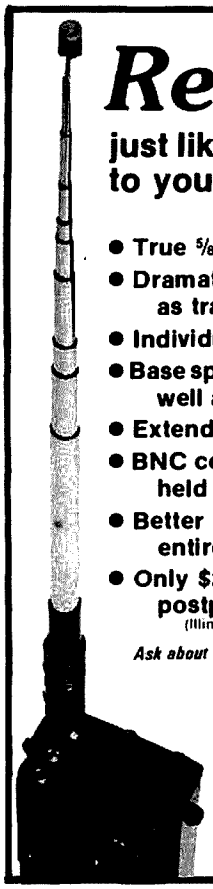
table 1. Dimensions for the Butterfly Beam (based on lower band edge).

dimension	band 10 meters	15 meters	20 meters
A	6′ (1.8 m)	8′ (2.4 m)	12′ (3.7 m)
B	4′3″ (1.3 m)	5′7″ (1.7 m)	8′6″ (2.6 m)
C	3′7″ (1 m)	5′ (1.5 m)	7′3″ (2.2 m)
D*	5′10″ (1.8 m)	7′9″ (2.4 m)	11′8″ (3.6 m)

Materials: X-arms are 1-inch (25.4 mm) diameter aluminum tubing; wire is soft-drawn aluminum ground wire, approximately 1/8-inch (3 mm) diameter; insulators are plastic, nylon cord is suitable. Hub is Lexan (see text).

*Assuming coaxial cable velocity factor = 0.66 Formula = 164/f(MHz).

*A better alternative is COAX-SEAL available from Universal Electronics, Inc., 1280 Aida Drive, Reynoldsburg, Ohio 43086.



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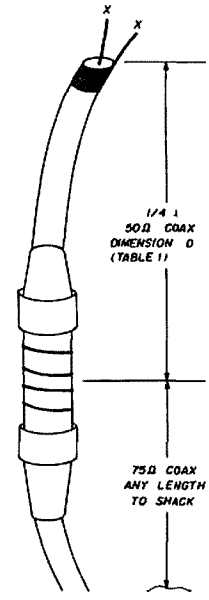


fig. 3. Typical means of constructing a quarter-wave matching section from coax. The feedpoint impedance of the beam (about 30 ohms) is transformed to the feedline impedance (72 ohms) by means of a quarter-wave transformer of 50-ohm coaxial cable. Accompanying table and notes show dimensions for various bands. Center connector consists of two male connectors joined by a female (barrel) connector, for convenience. Joint should be taped and waterproofed after completion.

represents a gain of 6 to 7 dB, and sometimes as much as 10 dB!

The front-to-back ratio runs only 10 to 15 dB, although the front-to-side ratio is considerably better, running about 30-40 dB. There seems to be a very deep notch in the position between side and back of the beam, although I have not made any pattern plots to verify this. A considerable improvement in front-to-back ratio might possibly be made by director tuning. Another interesting possibility is that of using a coaxial capacitor as a director tuning capacitor.

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ham radio

measuring coax cable loss with an SWR meter

One solution to the high cost of exotic test equipment for measuring transmission-line losses

Have you ever wondered how much loss a piece of coaxial cable has at a particular frequency? You could consult a chart or graph in a reference book. However, that would only tell you the *approximate* loss for coax from the manufacturer who supplied data to the editor of the book. Age and environment affect cable loss. Does the chart in the book include an age factor? The easiest way to determine loss in a piece of coax is by measuring it. You don't need expensive test equipment to do this. All you need is a) an SWR meter or a bidirectional wattmeter, b) a transmitter, and c) the desire to perform a few simple calculations.

By John W. Frank, WB9TQG, P.O. Box 5113, Madison, Wisconsin 53705

determining cable loss

The loss in coaxial cable can be determined by connecting it to a source of rf (the transmitter) and measuring the SWR at the transmitter when the far end of the line is an open circuit. At first this method may sound too simple to work, but it does, and here's why.

Transmission line theory tells us that the SWR will be:

$$SWR = \frac{R}{Z} \qquad (1)$$

where R is the load resistance, *and* Z *is the line impedance.*[1] An open circuit would present an infinite load resistance and therefore an infinite SWR. Trans-

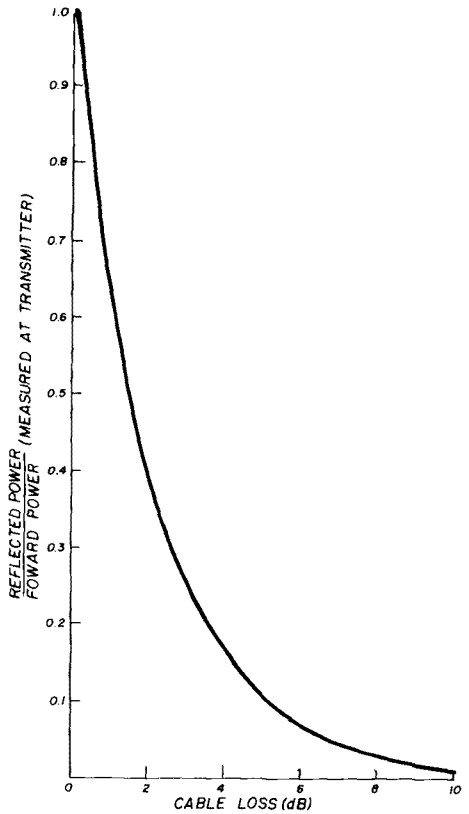


fig. 1. Ratio of reflected power to forward power as a function of cable loss (*eq. 4*).

mission line theory also tells us that the reflection coefficient[2] will be:

$$K = \frac{SWR - 1}{SWR + 1} \qquad (2)$$

Since the SWR of an open circuit will be infinite, the reflection coefficient will be, for all practical purposes, unity (100 per cent). Therefore, all the power reaching the end of the line will be reflected to the source.

However, not all the power from the source reaches the end of the line; some is lost along the way. And not all the reflected power returns to the source; some of it is also lost along the way.

The reflected power measured at the source represents twice the loss of the coax: the loss forward and loss reflected. The standard formula for calculating the dB loss or gain[3] is:

$$dB = 10 \log \frac{P1}{P2} \qquad (3)$$

In this application, **eq. 3** would tell us the loss for the round trip. Since we are interested in the loss in only one direction, and since the loss forward should be the same as the loss reflected, **eq. 3** becomes:

$$dB = 5 \log \frac{reflected}{forward} \qquad (4)$$

Eq. 4 is fine if you have a bidirectional wattmeter. Since many low-priced SWR meters measure SWR *without* indicating actual power in watts, and since SWR is a function of forward and reflected power, **eq. 4** can be transposed:

$$dB = 5 \log \left(\frac{SWR - 1}{SWR + 1} \right)^2 \qquad (5)$$

Eq. 4 is shown graphically in **fig. 1**. **Eq. 5** is shown in **fig. 2**.

examples

Before going any further, let's consider two simple hypothetical examples. A transmitter feeds 100 watts of rf power into a length of RG-58 cable. A bidirectional wattmeter at the transmitter indicates a reflected power of 25 watts. From **eq. 4** we can calculate

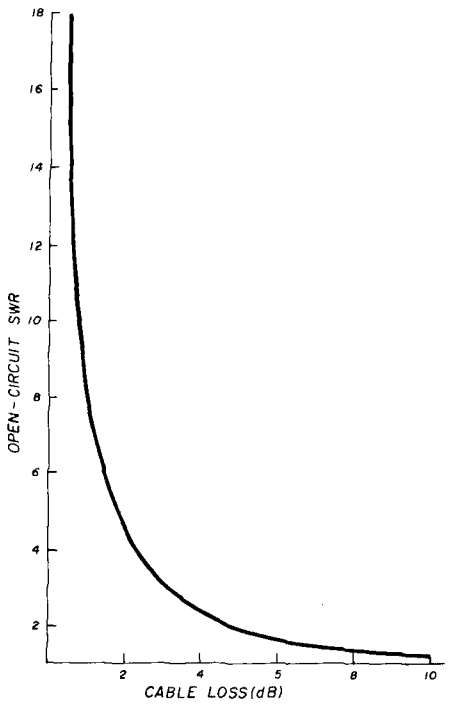


fig. 2. Open-circuit SWR as a function of cable loss (*eq. 5*).

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Nylon guy rope, 450 lb. test, 100' roll	3.49
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Belden 8219 RG-58 A/U foam coax ..... 50, 60, 75, 100, 125, 200, 300 and 1,000 ft. rolls	.12 ft
Berk-Tex 6211 RG-8X foam coax., Ultraflexible..... 50, 60, 75, 100, 125, 200, 300, and 500 ft. rolls	.16 ft.
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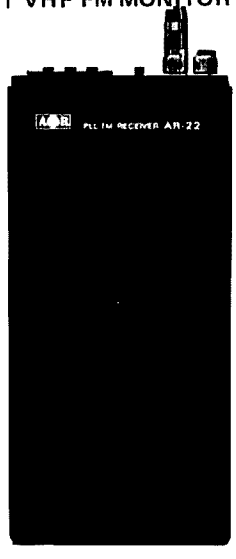
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$$5 \log \frac{25}{100} = 5 \log 0.25$$

$$= 5(-0.602) = -3.01\ dB \qquad (6)$$

The minus sign indicates a loss. To further verify **eq. 4**, let's consider what happened to the rf as it made its round trip through the coax. If the coax really did have **3** dB of loss, approximately 50 watts would reach the open end. When that 50 watts was reflected, the same 3 dB loss would result in *25 watts being lost in the coax*. Thus, only 25 watts would be measured as reflected power at the source.

For our second hypothetical case, let's assume the use of an SWR meter that doesn't indicate forward power; the meter scale reads directly in SWR. A transmitter of unknown output is connected to a length of RG-8/U cable, and the SWR at the transmitter is 6:1. We can use **eq. 5** to calculate the loss:

$$5 \log \left(\frac{6-1}{6+1}\right)^2 = 5 \log (0.714)^2$$

$$= 5(-0.29) = -1.45\ dB. \qquad (7)$$

Again, the minus sign indicates a loss.

system accuracy

This will depend on the accuracy of the SWR meter or wattmeter used to make the measurement. Several precautions must be observed:

1. Some lengths of coax at some frequencies could act as resonant circuits and cause inaccurate measurements.

2. Short lengths of good-quality coax will show a very high SWR. Make sure the transmitter used as a source of rf can withstand a high SWR.

3. The transmitter impedance must match that of the coax.

4. Measurements should be made at the frequency at which the coax will be used.

One more item must be taken into account. This system for measuring loss in coaxial cable assumes that the load will be perfectly matched to the line. Any mismatch will create standing waves that will cause additional loss.[4]

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ham radio

for pattern calculation phased vertical arrays

Solving pattern equations using a programmable calculator

The vertical, quarter-wave ground-plane or ground-mounted antenna is a popular choice. Much interest has been shown recently for vertical arrays in the Amateur literature. The vertical array can give good results in directivity for less investment than a rotatable antenna such as the Yagi or quad beam.

This article examines the procedures for pattern calculation of phased vertical arrays having arbitrary layout, antenna height, phasing, and power division among array members.

phased vertical arrays

Several classic vertical arrays have been implemented and described in the Amateur literature. Many Amateurs have obtained good performance with such antennas. However, several problems arise when constructing vertical arrays. Lack of appropriate real estate is foremost: the pattern of the classic array may not fit your location. You don't need to depend on a classic layout if one or more of the following is available:

1. A scientific calculator and a lot of time.
2. A programmable calculator and moderate amount of time.
3. A microcomputer and very little time.

All three depend on mathematical relationships, and these are shown for arrays of an arbitrary nature. Computation procedures are outlined.

A Hewlett-Packard HP-67/97 programmable calculator program is given, followed by the BASIC source code listing for a Radio Shack TRS-80 microcomputer. The latter will run on a Level-II machine with as little as 4k of memory. Both programs are adaptable to other machines, especially the computer program.

pattern equations

The directivity pattern of any antenna or array is three-dimensional in nature. Convention gives a plot of relative field strength at various angles, θ, above the horizon. Azimuth is fixed, and the pattern is defined relative to an array axis.

Conversely, patterns may be given in the horizon-

By Patrick McGuire, WB5HGR, 102 Duncan Circle, Lafayette, Louisiana 70503

tal plane with θ fixed and azimuth angle, ϕ, varying 0 to 360 degrees. **Fig. 1** is a pictorial description of both patterns.

Relative field strength of a single vertical antenna having sinusoidal current distribution and a current node at the top is given by:

$$f(\theta) = \frac{\cos(G \sin \theta) - \cos G}{(\cos \theta)(1 - \cos G)} \qquad (1)$$

where: $f(\theta)$ = Relative vertical field strength (N.D.)
G = Electrical height of antenna (degrees).
θ = Angle above horizon (degrees).

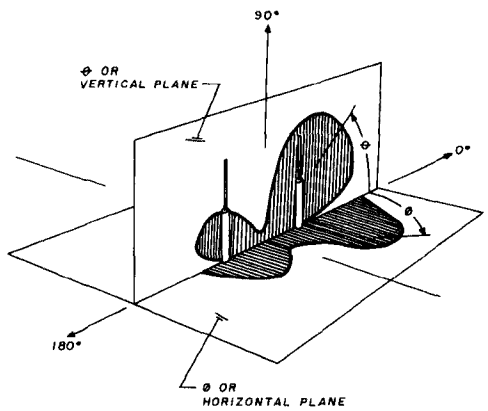


fig. 1. Two-dimensional representation of an array field strength.

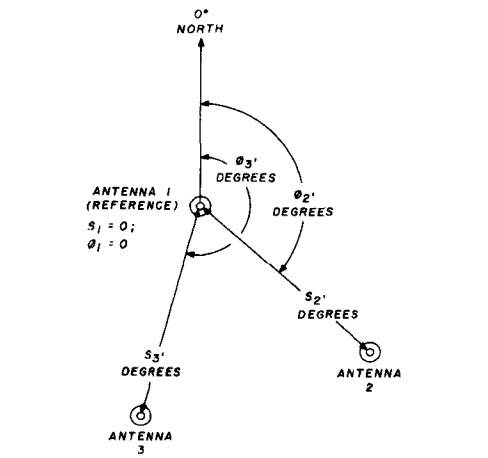


fig. 2. Geometric relationships of spacing and location, top view.

As an example, solution of **eq. 1** for a quarter-wavelength antenna requires G equal to 90 degrees. A zero value of θ (on the horizon) yields an $f(\theta)$ of unity; $f(\theta)$ will be zero for $\theta = 90$ degrees (straight up). All other angles of θ will yield a result between zero and one.

The field-strength pattern for a single vertical antenna in the horizontal (ϕ) plane is a circle. The composite field strength of an array of antennas in the ϕ plane is given by:

$$E = \sum_{k=1}^{n} E_k f_k(\theta) \angle B_k \qquad (2)$$

$$B_k = S_k(\cos \theta)[\cos(\phi_k - \phi)] + Y_k \qquad (3)$$

where E = Total relative field strength of all antennas in ϕ plane (N.D.)
E_k = Component of total field strength due to k^{th} antenna alone (N.D.)
$f_k(\theta)$ = Vertical field strength of the k^{th} antenna for the θ chosen for pattern calculation (N.D.)
B_k = Phase angle relationship of the field vector from the k^{th} antenna with respect to the reference (degrees)
S_k = Physical spacing of the k^{th} antenna with respect to the reference antenna (electrical degrees)
θ = Vertical angle chosen for the pattern and held constant for all ϕ angles (degrees)
Y_k = Relative drive phase of antenna k at its feed point with respect to the reference (degrees)
ϕ_k = Azimuth bearing from the array reference point to the k^{th} antenna (degrees)
ϕ = Azimuth bearing from the reference point in direction of interest (degrees)
n = Number of antennas in the array

Eqs. 2 and **3** are explained with the aid of a three-antenna array shown in **fig. 2**. An elevation angle, θ, is chosen for all horizontal angles, ϕ. **Eq. 1** is solved for each array antenna to yield $f(\theta)$; it may be considered constant for all values of ϕ. The array geometry will define S_k and ϕ_k.

One antenna must be a reference. Values of S_k, ϕ_k, Y_k, and B_k for this antenna will be zero; E_k value will be one. E_k values of the other antennas will be the ratio of drive power of the reference versus the other antennas. The value of other antenna drive-phase angles will be positive for lead, negative for lag.

The summation in **eq. 2** requires that **eq. 3** be solved first. The polar form of $[E_k f_k(\phi) \angle B_k]$ is then converted to rectangular form, summing the real and im-

table 1. Hewlett-Packard HP-67 program listing.

STEP	KEY ENTRY	KEY CODE	STEP	KEY ENTRY	KEY CODE	STEP	KEY ENTRY	KEY CODE
001	f LBL A	31 25 11	041	0	00	081	CHS	42
002	0	00	042	STO 2	33 02	082	1	01
003	STO 2	33 02	043	STO 3	33 03	083	+	61
004	STO 3	33 03	044	f GSB 1	31 22 01	084	RCL 0	34 00
005	STO 1	33 01	045	RCL 3	34 03	085	f Cos	31 63
006	f LBL 2	31 25 02	046	RCL 2	34 02	086	x	71
007	f GSB 1	31 22 01	047	g R → P	32 72	087	h 1/x	35 62
008	RCL 1	34 01	048	h RTN	35 22	088	RCL (i)	34 24
009	h PAUSE	35 72	049	f LBL D	31 25 14	089	f Cos	31 63
010	RCL 3	34 03	050	STO 0	33 00	090	CHS	42
011	RCL 2	34 02	051	0	00	091	RCL 0	34 00
012	g R → P	32 72	052	STO 2	33 02	092	f Sin	31 62
013	R/S	84	053	STO 3	33 03	093	RCL (i)	34 24
014	RCL 4	34 04	054	f GSB 1	31 22 01	094	f DSZ	31 33
015	STO + 1	33 61 01	055	RCL 3	34 03	095	x	71
016	0	00	056	RCL 2	34 02	096	f Cos	31 63
017	STO 2	33 02	057	g R → P	32 72	097	+	61
018	STO 3	33 03	058	h RTN	35 22	098	x	71
019	GTO 2	22 02	059	f LBL 1	31 25 01	099	RCL (i)	34 24
020	f LBL B	31 25 12	060	9	09	100	f DSZ	31 33
021	0	00	061	h STi	35 33	101	x	71
022	STO 2	33 02	062	f GSB 0	31 22 00	102	RCL (i)	34 24
023	STO 3	33 03	063	1	01	103	f DSZ	31 33
024	STO 0	33 00	064	4	04	104	RCL 1	34 01
025	f LBL 3	31 25 03	065	h STi	35 33	105	-	51
026	f GSB 1	31 22 01	066	f GSB 0	31 22 00	106	f Cos	31 63
027	RCL 0	34 00	067	1	01	107	RCL 0	34 00
028	h PAUSE	35 72	068	9	09	108	f Cos	31 63
029	RCL 3	34 03	069	h STi	35 33	109	x	71
030	RCL 2	34 02	070	f GSB 0	31 22 00	110	RCL (i)	34 24
031	g R → P	32 72	071	2	02	111	f DSZ	31 33
032	R/S	84	072	4	04	112	x	71
033	RCL 4	34 04	073	h STi	35 33	113	RCL (i)	34 24
034	STO + 0	33 61 00	074	f GSB 0	31 22 00	114	+	61
035	0	00	075	h RTN	35 22	115	h x ⇆ y	35 52
036	STO 2	33 02	076	f LBL 0	31 25 00	116	f P → R	31 72
037	STO 3	33 03	077	RCL (i)	34 24	117	STO + 2	33 61 02
038	GTO 3	22 03	078	f X=0 ?	31 51	118	h x ⇆ y	35 52
039	f LBL C	31 25 13	079	h RTN	35 22	119	STO + 3	33 61 03
040	STO 1	33 01	080	f Cos	31 63	120	h RTN	35 22

aginary parts separately, then converting the final summation back to polar form.*

The result at any given ϕ is in the form $E \angle B$ with E being the magnitude of relative field strength at azimuth ϕ. Resultant angle B is unimportant at far distances, but all B_k angles must be calculated as indicated for solution of **eq. 2**.

example

To illustrate, consider a simple array of two quarter-wave vertical antennas spaced 120 electrical degrees on a north-south bearing. With the south antenna as the reference, the north antenna is fed with equal power but at a phase lead of 60 degrees. Initial data is then (numbers in electrical degrees):

antenna	G	ϕ	S	E	Y
1 (reference)	90	0	0	1	0
2	90	0	120	1	60

Set θ equal to zero. Since $G_1 = G_2$ **eq. 1** solutions are identical and:

$$f_1(0) = f_2(0) = \frac{\cos(90^\circ \times \sin 0^\circ) - \cos 90^\circ}{(\cos 0^\circ)(1 - \cos 90^\circ)}$$

$$= \frac{\cos 0^\circ - \cos 90^\circ}{1(1-0)} = \frac{1-0}{1} = 1$$

*The Greek letter sigma in **eq. 1** means the summing of all individual k-subscript terms calculated separately in the form to the right of sigma. The **fig. 2** example would have k values of 1, 2, and 3, since $n = 3$. **Editor**.

Choose the first azimuth of interest to be 15 degrees. **Eq. 3** values are then

$$B_1 = 0°[(\cos 0°) \times \cos(0° - 15°)] + 0° = 0°$$

$$B_2 = 120°[(\cos 0°) \times \cos(0° - 15°)] + 60°$$

$$= 120 \times 1 \times \cos(-15°) + 60°$$

$$= 120 \times 0.966 + 60 = 175.92°$$

Equal power magnitude is at each feedpoint, so $E_1 = E_2 = 1$. From **eq. 2**

$$E = [E_1 f_1(0) \angle B_1] + [E_2 f_2(0) \angle B_2]$$

$$= [1 \times 1 \angle 0°] + [1 \times 1 \angle 175.92°]$$

$$= (1 + j0) + (-0.997 + j0.071)$$

$$= (1 - 0.997) + j(0 + 0.071)$$

$$= 0.003 + j0.071$$

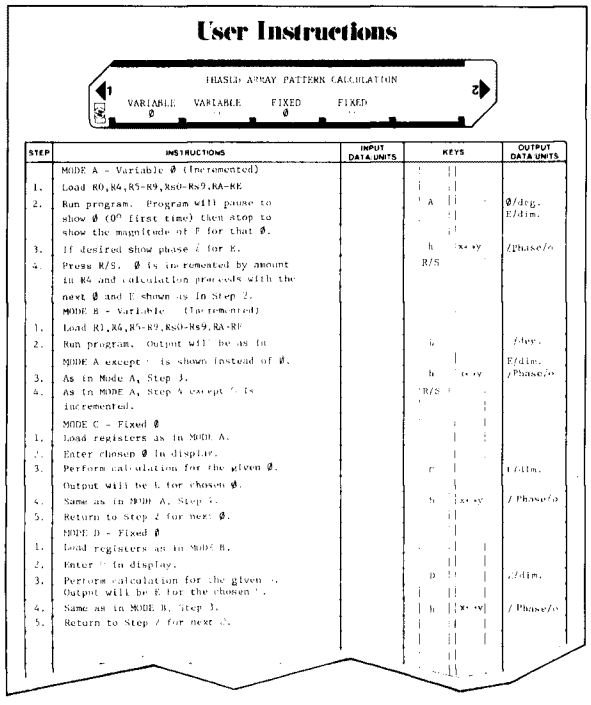
$$= 0.0711 \angle 87.58°$$

Maximum relative magnitude of a double, equal size and power antenna array is 2. The low magnitude at 15 degrees east of north indicates a null in the northerly direction.

Calculations may be carried out for all azimuths of interest or in a series from zero to **360** degrees for pattern plotting. For example, this array has a field strength of $1.732 \angle -29.9°$ at $\phi = 180°$; gain exists toward the south. Numerical solution steps are left as an exercise.

Keeping a constant elevation angle, θ, requires only one solution of **eq. 1**. **Eq. 3** must still be solved at each azimuth.

table 2. Operating instructions for the HP-67 calculator program.



User Instructions

PHASED ARRAY PATTERN CALCULATION

VARIABLE Ø | VARIABLE Ø | FIXED Ø | FIXED Ø

STEP	INSTRUCTIONS	INPUT DATA UNITS	KEYS	OUTPUT DATA UNITS
	MODE A - Variable Ø (Incremented)			
1.	Load R0,R4,R5-R9,R50-R59,RA-RE			
2.	Run program. Program will pause to show Ø (0° first time) then stop to show the magnitude of E for that Ø.		A	Ø/deg. E/dim.
3.	If desired show phase ∠ for E.		h x≷y	∠Phase/o
4.	Press R/S. Ø is incremented by amount in R4 and calculation proceeds with the next Ø and E shown as in Step 2.		R/S	
	MODE B - Variable (Incremented)			
1.	Load R1,R4,R5-R9,R50-R59,RA-RE			
2.	Run program. Output will be as in MODE A except Ø is shown instead of Ø.		b	Ø/deg. E/dim.
3.	As in Mode A, Step 3.		h x≷y	∠Phase/o
4.	As in MODE A, Step 4 except Ø is incremented.		R/S	
	MODE C - Fixed Ø			
1.	Load registers as in MODE A.			
2.	Enter chosen Ø in display.			
3.	Perform calculation for the given Ø. Output will be E for chosen Ø.		c	E/dim.
4.	Same as in MODE A, Step 3.		h x≷y	∠Phase/o
5.	Return to Step 2 for next Ø.			
	MODE D - Fixed Ø			
1.	Load registers as in MODE B.			
2.	Enter Ø in display.			
3.	Perform calculation for the given Ø. Output will be E for the chosen Ø.		D	E/dim.
4.	Same as in MODE B, Step 3.		h x≷y	∠Phase/o
5.	Return to Step 2 for next Ø.			

using a programmable calculator

Computations are greatly simplified through the use of a programmable calculator such as the Hewlett-Packard HP-67 or HP-97. **Table 1** is a flexible program for the HP-67.* This program can handle up to four antennas in an arbitrary array and can be used in four modes.

Mode A operates with a fixed elevation angle, θ. Azimuth increment is stored in register 4 after loading required data in registers indicated in step 1. Initial computation is begun by pressing function key A. The first stop indicates field strength magnitude at zero azimuth. Pressing the R/S key causes the *working-*ϕ to be incremented by the amount in register 4; next stop will show field strength magnitude at the next azimuth. This may be repeated by pressing the R/S key for each azimuth increment until the entire pattern is described.

Mode B is similar except azimuth is held constant, and the output describes the vertical plane pattern. The value in register 4 is the incremental elevation angle, θ. Initial calculation is zero elevation after pressing function key B.

Mode C calculates field strength at any azimuth manually entered before pressing function key C. Mode D is similar except the calculation is made on entered elevation angles.

Program instructions are given in **table 2**. Preloading of all registers except 2 and **3** is required for each array. Zero is loaded into registers designated for unused antennas.

a basic computer program

Ultimate ease of calculation is with a computer. **Table 3** is a program written in BASIC for the Radio Shack TRS-80, Level II microcomputer. The program requires only 4k of RAM, the minimum configuration for this machine. It will run on other BASIC language computers with minimal alteration.

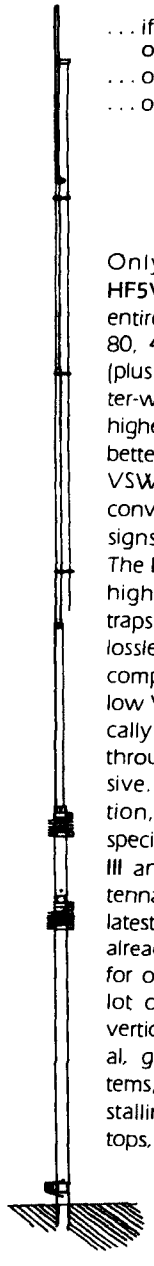
The program is largely self-prompting, given an understanding of the terms in this article. It allows initial entry of all antenna data, an increment value for ϕ, and elevation angle θ. Subsequent runs do not require full data re-entry; the user may branch to a data alteration routine for specific changes, then re-run.

Coding and formatting is for CRT monitor output. Printer tabulation is possible by changing PRINT to LPRINT in lines 250, 251, 255, 256, 1020, and 1022. A sample output at azimuth increments of **15** degrees is given in **table 4** for the previous two-antenna array.

*A few simple changes allow operation on the HP-97. Consult the owner's manual for 67/97 differences.

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table 3. BASIC program listing for the Radio Shack TRS-80. This may be used for other BASIC interpreters with appropriate language alteration.

```
10 CLS:PRINT TAB(21)"VERTICAL ANTENNA ARRAYS":PRINT
20 PRINT TAB(16)"DIRECTIONAL PATTERN COMPUTATION":PRINT:PRINT
30 INPUT"ENTER THE NUMBER OF ANTENNAS IN THE ARRAY";NANT:CLS
40 PRINT TAB(20)"DATA ENTRY INSTRUCTIONS":PRINT
50 PRINT TAB(6)"CHOOSE A REFERENCE POINT FOR THE ARRAY TO BE"
60 PRINT"ONE OF THE ANTENNAS THEREIN. THEN THE POSITION AND"
70 PRINT"EXCITATION DATA FOR ALL OTHER MEMBERS OF THE ARRAY"
80 PRINT"ARE TO BE SPECIFIED WITH RESPECT TO THIS REFERENCE."
90 PRINT TAB(6)"FOR EACH ANTENNA THE COMPASS BEARING FROM THE"
100 PRINT"REFERENCE TO IT;(THE AZIMUTH) MUST BE ENTERED. NEXT,"
110 PRINT"THE DISTANCE TO THE REFERENCE IN ELECTRICAL DEGREES"
120 PRINT"IS ENTERED. FINALLY ENTER THE DRIVE PHASE LEAD OR LAG"
130 PRINT"RELATIVE DRIVE AND ELECTRICAL HEIGHT."
135 PRINT TAB(6)"THE AZIMUTH, PHASE, AND SPACING MUST BE 0."
136 PRINT"AND RELATIVE DRIVE POWER 1 FOR THE REFERENCE.":PRINT
140 INPUT"PRESS ENTER TO BEGIN DATA ENTRY SEQUENCE";DUM:CLS
150 DIM A(NANT,5):DIM PL(4,2)
160 FOR I=1 TO NANT
170 PRINT TAB(19)"INPUT, FOR ANTENNA NO. "I:PRINT
180 INPUT"AZIMUTH, DEGREES";A(I,1)
190 INPUT"SPACING, DEGREES";A(I,2)
200 INPUT"PHASE,   DEGREES";A(I,3)
210 INPUT"RELATIVE POWER INPUT, DIMENSIONLESS";A(I,4)
215 INPUT"ELECTRICAL HEIGHT, DEGREES";A(I,5):CLS:NEXT
220 GOSUB 700
230 GOSUB 800
235 PRINT
240 CLS:INPUT"ENTER DATA OUTPUT AZIMUTH INCREMENT, DEGREES";INC
245 INPUT"ENTER VERTICAL ELEVATION ANGLE, DEGREES";THETA:CLS
250 PRINT TAB(10)"RELATIVE FIELD STRENGTH CALCULATION RESULTS"
251 FOR Q=1TO64:PRINT"-";
252 NEXT Q
255 PRINT TAB(20)"ELEVATION ANGLE =";THETA:C$="AZ. = RFS"
256 PRINT TAB(1);C$;TAB(16);C$;TAB(31);C$;TAB(46);C$
260 I=0
270 J=0
274 SX=0:SY=0
275 FOR M=1 TO NANT
280 GOSUB 950
284 NEXT M
285 RFS=SQR(SX^2.+SY^2.)
290 J=J+1:PL(J,1)=I:PL(J,2)=RFS
300 IF I=360 THEN 1000
310 I=I+INC:IF I>360 THEN I=360
320 IF J=4 THEN 1000
330 GOTO 274
335 PRINT:PRINT"ENTER 0 TO COMPLETELY RERUN"
340 INPUT"ENTER 1 TO REVISE DATA AND RERUN";T:CLS
350 IF T=1 THEN 220:IF T=0 THEN 360
360 RUN
700 CLS:PRINT TAB(1)"ANT.";TAB(31)"REL.";TAB(39)"REL.PWR";
705 PRINT TAB(49)"ELECT."
710 PRINT TAB(2)"#";TAB(8)"AZIMUTH";TAB(19)"SPACING";
720 PRINT TAB(30)"PHASE";TAB(40)"INPUT";TAB(49)"HEIGHT":PRINT
730 FOR K=1 TO NANT:PRINTTAB(1)K;TAB(10)A(K,1);TAB(20)A(K,2);
740 PRINT TAB(30)A(K,3);TAB(41)A(K,4);TAB(50)A(K,5):NEXT
750 RETURN
800 PRINT:INPUT"DATA OK? ENTER 1, ENTER 2 TO CHANGE DATA";X
810 ON X GOTO 840,850
820 GOSUB 700
830 GOTO 800
840 RETURN
850 GOSUB 900
860 GOSUB 700
870 GOTO 800
900 GOSUB 700
910 INPUT"ENTER ANTENNA #, COLUMN #, REVISED DATA";X,Y,Z
920 Y=Y-1:A(X,Y)=Z:RETURN
950 C=.0174553:AZK=A(M,1)*C:AA=I*C:PH=A(M,3)*C:U=A(M,5)*C
951 EL=THETA*C:NUM=COS(U*SIN(EL))-COS(U):DEN=COS(EL)*(1-COS(U))
952 F0=NUM/DEN:EFE=F0*A(M,4)
960 BK=A(M,2)*C*COS(AZK-AA)+PH:X=EFE*COS(BK):Y=EFE*SIN(BK)
970 SX=SX+X:SY=SY+Y:RETURN
1000 TB=-15
1010 FOR L=1 TO 4
1020 TB=TB+15:PRINT TAB(TB)USING"###";PL(L,1);:PRINT"=";
1022 TC=TB+6:PRINT TAB(TC)USING"#.##";PL(L,2);
1030 IF PL(L,1)=360 THEN 335
1035 NEXT L
1036 PRINT
1040 GOTO 270
```

construction cautions

Inadequate ground radial installation will reduce any vertical antenna performance. Improper radials will change both field strength and pattern depending on local ground conductivity.

Hardware implementation must match the calculation model. Antenna spacings should reflect the center of the band of interest. Phasing lines should be cut for both center of band and for the velocity of propagation of the line. Band-edge patterns can be checked by recalculation. Calculation spacings and length will change inversely proportional to frequency.

Each antenna must be matched to its own feedline. A good power divider must be used at the common feedpoint. Broadband division should be used to reduce phase unbalance on phasing lines. Simply connecting phasing lines in parallel at the common point will cause an impedance mismatch.

table 4. Example tabulation of computer program of the two-antenna array described in text.

elevation angle = 0

AZ. =	RFS	AZ. =	RFS	AZ. =	RFS	AZ. =	RFS
0 =	0.00	15 =	0.07	30 =	0.28	45 =	0.60
60 =	1.00	75 =	1.40	90 =	1.73	105 =	1.94
120 =	2.00	135 =	1.95	150 =	1.85	165 =	1.77
180 =	1.73	195 =	1.77	210 =	1.86	225 =	1.95
240 =	2.00	255 =	1.94	270 =	1.73	285 =	1.40
300 =	1.00	315 =	0.60	330 =	0.28	345 =	0.07
360 =	0.00						

ENTER 0 TO COMPLETELY RERUN
ENTER 1 TO REVISE DATA AND RERUN?

Close spacings will cause a slight individual antenna impedance change due to mutual coupling. This can be checked with a noise bridge for each antenna, all other antennas loaded. Amateur literature contains information on all of these factors and a bit of study is recommended.

Recognizing the factors beforehand should show any problems. The reference gives a complete discussion of the vertical array. This work was the mathematical basis for this article.

reference

Carl E. Smith, *Theory and Design of Directional Antennas*, Smith Electronics, Inc., 8200 Snowville Rd., Cleveland, Ohio 44141, approximately $6.00 plus postage.

bibliography

Reference Data for Radio Engineers, Sixth Edition, Howard W. Sams & Co., Inc., 1975. Page 27-6 contains the general field formula of a vertical antenna; page 27-22 contains the general array formula.

ham radio



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160 meters today

Have you looked closely at some of the beautiful full-color advertisements of the new generation of Amateur transceivers? Very interesting. And they are advertising *nine high-frequency bands. I'm sure you* are aware by now of the forthcoming 10, 18, and 24.5 MHz bands that are a result of the last WARC Conference. These bands are on the bandswitch of the newer transceivers. And look! They also have a switch position for 1.8 MHz. That's the 160-meter band.

A quick look-see across the 160-meter band by the proud owner of the "all-band" transceiver usually proves to be a disappointment. Perhaps one or two weak signals, some shot-type interference (Loran navigation signals) and plenty of rough QRM from the sweep oscillators of nearby TV receivers. And if the listener is unlucky, he'll get a blast of nasty noise from a light dimmer or two. Seems hopeless, doesn't it?

"top band"

Once the backbone of Amateur Radio, the 160-meter band has languished since World War II. During that distressing period, the Long Range Navigation System (LORAN) was placed in this region and the band has never been the same since.

Now, with the coming demise of LORAN in this frequency range, and the expansion of the band in the United States and overseas, 160 meters has a bright and promising future.

The casual tuner across 160 meters, unfortunately, gets an inaccurate impression of the band, particularly if he is listening on a nondescript antenna. Hook a good antenna on the receiver and, given a break in sweep oscillator QRM, an observant Amateur will find the band full of interesting signals at certain seasons and times of the day. A lot of activity takes place on 160, and there will be more in the future!

At the dawn of Amateur Radio, some years before World War I, Radio Amateurs — a few hundred of them — started out with crude spark transmitters and coherer receivers. It was difficult to tell what frequencies were in use; the spark transmitter took up a good chunk of the spectrum. Wavelength of operation was moot until the Radio Act of 1912, which removed Amateurs from the long wavelengths and restricted them to the "useless waves" below 200 meters.

Finally, as a result of heroic efforts of the American Radio Relay League, Amateur Radio became less chaotic and, after the war was over, Amateur Radio grew rapidly, with hundreds of stations operating in the 150 to 200 meter region. By 1922, worldwide

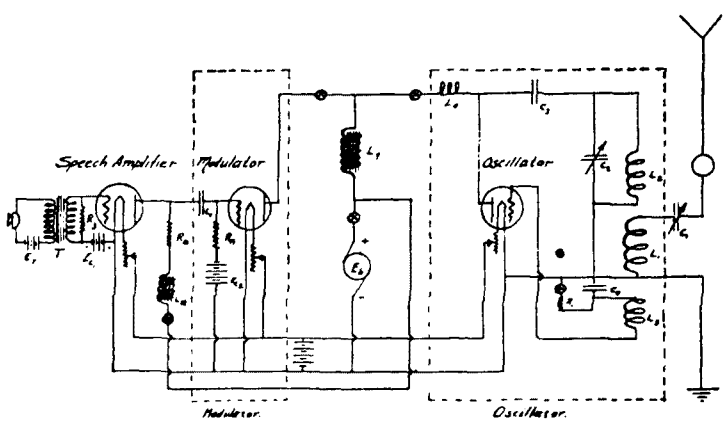


fig. 1. An early "constant-current" phone transmitter. Audio signal applied to the modulator tube varied its plate resistance and amount of current flowing through it. A large inductor (L1) in series with plate voltage to modulator and oscillator tube resists variations in current flow. Consequently when modulator draws a high level of current, oscillator current is reduced. Sum of two currents remained constant — hence the name. Drawing is from *Fifty Years of A.R.R.L.* published by the American Radio Relay League.

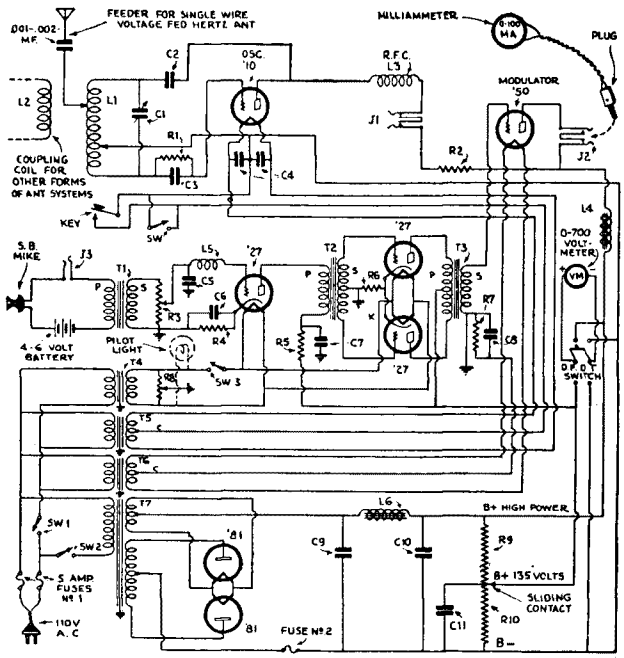


fig. 2. The 1930 phone transmitter of L.B. Robbins, W1AFQ. The 210 oscillator runs about 20 watts input from a 500-volt supply. The 250 tube modulator provides about 60-percent modulation. The tuned circuit consists of a copper tubing coil, 20 turns of 1/4-inch tubing, four inches in diameter and spaced out the tubing diameter. The capacitor is 500 pF. The coil is adjusted so that operation at the desired frequency occurs with the capacitor nearly fully meshed. The bias resistor of the modulator (R7) is adjusted until the no-signal plate dissipation of the 250 tube is about 24 watts. Believe it or not, a modern version of this antique transmitter is on the air today and it sounds quite good! (The drawing is from the August - September, 1931 issue of *Short Wave Craft* magazine, published by Popular Book Corporation.)

Amateur communications was possible, and it was noted that as wavelengths grew shorter, DX improved. The exodus from the 200-meter region seemed to be certain.

In 1924, the Department of Commerce assigned new bands for American Radio Amateurs centered about 80, 40, 20, and 5 meters. Development of the shorter waves was underway! An assigned 160-meter band was largely forgotten in the rush to high-frequency DX.

the 160-meter doldrums

Between 1924 and 1930 there was little interest in 160 meters, as exciting things were happening elsewhere. But the years between 1929 and 1934 were boom years for Amateur Radio. And there was a great and growing interest in telephony. Up to this date, there was little information and little interest in phone transmission. It was the exclusive domain of those few Amateur-engineers who knew their onions. And besides, voice transmission was very expensive.

About 1930, the collapse of the broadcast-receiver building boom turned many experimenters into the more interesting field of shortwave broadcasting. In a year or so, hundreds of thousands of "shortwave listeners" sprang up, and many of those switched to Amateur Radio. Amateur phone, especially for the beginner, was extremely restricted: no phone on the 40-meter band and a class-A license requirement for phone on 80 and 20 meters. And, of course everybody knew that 10 and 5 meters were useless: short-range bands on which it was almost impossible to get equipment working! So that left 160 meters for the beginning phone ham.

the rebirth of 160 meters

Amateur Radio really took off in 1932-33. In 1931 there were about 23,000 U.S. Amateurs. In 1932 there were about 30,000 and in 1933 about 42,000. By early 1934 the Amateur population of the U.S. had doubled the 1931 figure!

The boom in phone operation first started on 160 meters, to be followed in a year or so by practical use of the 5-meter band. But the 160-meter band was the beginner's phone band for a few Golden Years.

It was relatively easy to get going. The famous "constant current" (Heising plate modulation) circuit would do the job, and the modulated oscillator of 1921 (**fig. 1**) could be modernized for 160 meters (**fig. 2**). This simple circuit was very popular until the famous "46 job" came along in mid-1932 (**fig. 3**). The "46 job" was the ultimate phone transmitter, that brought about the explosion of 160-meter activity from 1933 to 1940. For well under a hundred dollars the lowly Class B Amateur could go on phone and enjoy himself!

what 160 meters was like

What was 160 meters like during the winter months of 1934? During the day there wasn't much activity until late in the afternoon when the high-school crowd got home. And

then from about 3 to 6 pm the band was full of low-power phone operators. In the New York area there were literally hundreds of phones, running from 10 to 50 watts — and most of them were licensed. In truth, there was a good amount of bootlegging — enthusiasts who hadn't gotten around to making a trip to the FCC for the ham exam. They just "borrowed" a call and went on the air. Next higher in social acceptability were the unlicensed operators who borrowed a ham friend's call. And finally, the "kings of the band," the newly licensed Amateurs.

By 5 pm the older Amateurs started coming home from work, and the disposition of the band changed. The bootleggers disappeared, and the call-borrowers subsided. The interference level picked up sharply as the "old timers" with their 100- and 250-watt phone transmitters gradually took over.

When evening came the band was bedlam. Only the Old Timers remember what a phone band sounded like when it was loaded with a-m phones. Newer hams can get the idea by listening to the CB channels. It was the survival of the fittest. You could judge your transmitter's ability by the DX you worked. From New York City, most low-power phones could work up into Canada. Given a little luck, they could work into Florida late at night when the bedlam had died down. And the *real* DXers — the sturdy fellows who stayed up into the early morning hours — could prove themselves by working into California if conditions were just right!

But the majority of young Amateurs enjoyed 160 meters during the daylight hours and were content to work their friends in the immediate area. Since most stations were crystal controlled (the modulated oscillator quickly dying out as the band population grew), you knew the fellows who operated near your frequency. Stations on the other end of the band were a mystery, known only to those fortunates who owned two crystals!

It was rumored that transatlantic contacts were possible, and some of the better stations got listener cards from "across the pond." And almost everyone on 160-meter phone got SWL (shortwave listener) cards from local would-be hams. The old a-m transmitters were easy to tune in, even with the most rudimentary receiver.

All this bee hive of activity came to a close on December 7, 1941.

the post-war band

After the war, the 160-meter band was revived, but it was divided up into segments based on proximity of Loran networks. A bewildering set of restrictions and regulations crippled the band, and 160-meter operation was not licensed in many countries. This stalemate continued for many years and only a few hardy souls operated on the band. True, it would come to life a bit during a DX contest, but since most ham gear didn't cover the band, it became lifeless during the fifties as the interest in SSB grew.

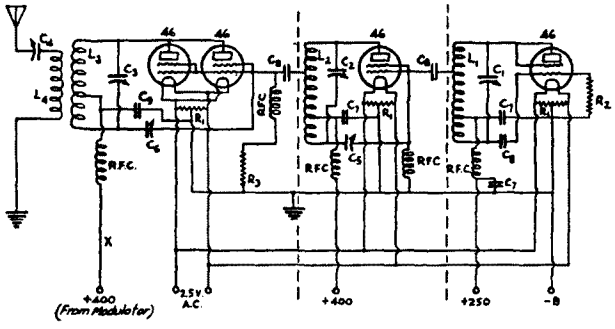


FIG. 1 — WIRING DIAGRAM OF THE RADIO-FREQUENCY END

C_1 — 500-$\mu\mu$fd. variable condenser.
C_2, C_3, C_4 — 250-$\mu\mu$fd. variable condensers.
C_5 — 100-$\mu\mu$fd. midget condenser.
C_6 — 50-$\mu\mu$fd. midget condenser.
C_7 — 005-μfd. fixed condensers.
C_8 — 250-$\mu\mu$fd. fixed condensers.
C_9 — 001-μfd. fixed condenser.
R_1 — 20-ohm center-tapped resistor.
R_2 — 50,000-ohm, 1-watt resistor.
R_3 — 1000-ohm, 2-watt resistor.
RFC — Radio-frequency chokes, Silver-Marshall Type 275 or equivalent.
L_1 — 17 turns of No. 12 enamelled wire, spaced to occupy 2½ inches on 2½-inch diameter form, tapped at 5th turn from grid end. Buffer excitation tap at 10th turn from plate end.
L_2 — Plate portion: 30 turns No. 18 enamelled, spaced to occupy 1½ inches on 2½-inch diameter form, tapped at 23rd turn from plate end for excitation to following stage. Neutralizing portion: 12 turns same spaced to occupy ¾-inch on same form, ½-inch away from plate portion.
L_3 — 38 turns of No. 14 enamelled wire, spaced to occupy 3½ inches on 2½-inch diameter form, tapped at center.
L_4 — 30 turns of No. 18 enamelled wire on 1½-inch diameter form; no spacing between turns.
Key or keying relay may be placed at X for c.w. transmission.

fig. 3. The famous "46 job." This 40-watt transmitter was popular on 160 meters in the prewar period. The class-B modulator and driver also used type 46 tubes. Many builders substituted a crystal oscillator in place of the self-excited oscillator (tube at right). Illustration from *QST*, August, 1932.

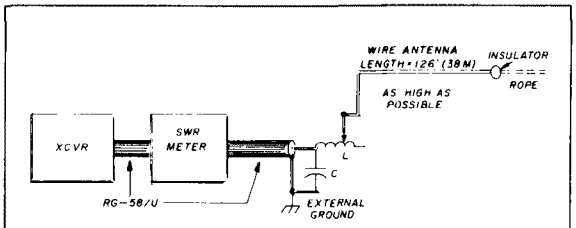


fig. 4. Simple Marconi antenna for 160 meters. Variable capacitor (C) is 400 pF. Inductor (L) is airwound coil, 2 inches in diameter, 8 turns per inch, 4 inches long (32 turns). Inductor is adjusted for lowest SWR when capacitor is adjusted to provide 50-ohm load. Both devices may be simply adjusted for lowest SWR on the meter. Antenna wire should be as high as possible. See text for information on ground connection. Note that the antenna may be made shorter, but more inductance is required in the coil.

160 meters today

Interest is again growing in this old-time band. Most new transceivers cover the band, and the Loran networks are being rapidly phased out. And it looks as if the band will be expanded to near its pre-war dimensions in a few months. As a result of the recent WARC Conference, Amateurs in many foreign countries who never had this band can now enjoy operation in certain selected segments. During DX contests, the band is jumping, and more and more Amateurs look to 160 meters for reliable, short-range daylight communications.

During the week the band is relatively quiet through the daylight hours. At night, things pick up a bit. Most CW operation falls between 1800 and 1810 kHz. Sideband occupies the region immediately above this segment. (In some areas of the country operation is permitted at the high-frequency end of the band, and certain power-input restrictions apply. See the current edition of the ARRL *Handbook* for details.)

On contest weekends the band is alive with plenty of overseas DX coming through. A handful of WACs have been made on 160, along with a few prized DXCC awards. But it is not the typical station that achieves these results!

More and more Amateurs are experiencing the fun of working 160. It is entirely different from the other bands. All you need to get in the action is a good antenna.

a practical antenna for 160 meters

Any antenna design capable of working on the other high-frequency bands will operate on 160 meters. Size is the problem. A half-wavelength at 1850 kHz is 253 feet (77 meters) and at 1950 kHz it is 240 feet (73 meters). That rules out a coaxial-fed dipole for most Amateurs. Those lucky enough to have the room would be well advised to erect a dipole for 160 meters as high as possible.

The next best bet is an end-fed quarter-wave Marconi antenna (**fig. 4**). The antenna shown will operate at any frequency in the band when properly adjusted for the lowest SWR reading. The antenna uses ground as the return circuit and one of the chief problems of obtaining good performance is that of getting a good ground connection.

If the residential water system is made of copper tubing, it may be used for a radio ground. Connection should be made by a short, heavy lead to a nearby cold-water pipe. Flexible braid removed from a defunct length of old RG-8/U coaxial cable makes a good ground lead.

Not all piping systems make a good ground, and it may be necessary to drive several rods into the ground and connect them to the water pipes. You'll have to experiment with this.

Another idea used on 160 meters is the radial ground. This is an insulated wire a quarter-wavelength long (about 126 feet for operation at the low end of the band). One end of the wire is attached to the common ground point of the transmitter, and the wire is run along near (but not touching) the ground. I use a radial ground wire in conjunction with a water pipe ground for 160-meter work, and it seems to be a good combination.

The radial ground wire can run through bushes or along a fence. The far end of the wire should be covered with tape because it can be "hot" with rf during transmission.

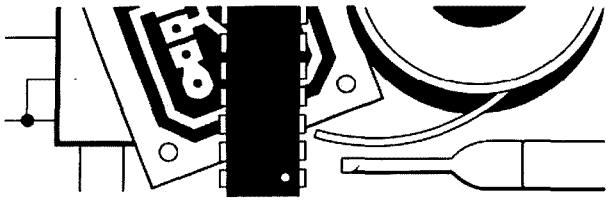
Once you get on the band and make contact with a few stations, you'll find out a lot more about 160-meter antenna systems. Some of the better stations have quite exotic antennas. The vertical antenna is much prized; a station with a good vertical antenna and a fine ground system can really place a big signal on the band. But for everyday operation and a lot of fun, a simpler antenna will do the job.

When operating this band it's interesting to think that these frequencies are the oldest operating range for Amateur Radio and that you are following in the footsteps of a lot of famous Amateurs and experimenters. And no doubt a lot of interesting experimental work is going on in this band right now. Some Amateurs are experimenting with loop antennas for low-noise reception as well as large Beverage antennas. And there are some experimental beam antennas on 160 meters, too!

But why spoil your fun? Get on this reborn Amateur band yourself and take part in the interesting work going on today!

ham radio

the weekender



plumber's delight coax connector

About three years ago while looking over flea-market offerings at a ham convention, surplus TV hardline coax cable caught my eye. The coax line was quite inexpensive, but the connectors were expensive and difficult to obtain. To make a long story short, the line I brought home ended up in my already cluttered garage. For the next year or so I wondered just why I had bought it and what I was going to do with it. One day, while sorting some copper-plumbing fittings, I had an idea. I have a plumber's delight beam, so why not a plumber's delight connector?

The result was a successful connector for which I make the following claims:

1. Low cost (approximately $1.50 each).
2. Long life.
3. Waterproof.
4. Makes a rigid connection.
5. Material readily available.
6. No great skill needed.
7. Can be removed and disassembled for inspection.

Only one possible problem was noted: a ½-inch pipe die is required. This is really not too difficult. A pipe die may be obtained by purchase or rental.

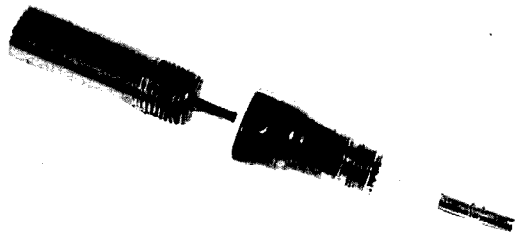
The following material covers only 3/4-inch coax hardline. Copper fittings for other sizes, 1/2 and 1 inch, I believe, are also obtainable. So if you have coax other than 3/4 inch, check with plumbing-supply houses.

First off, 1/2-inch iron or steel pipe has an outside diameter of 3/4 inch. Only two parts are needed to make the new connector, (1) a copper-plumbing connector to join 1/2-inch OD copper tubing to 1/2-inch threaded pipe (3/4-inch OD), and (2) a double female coax connector, PL-258.

By James R. Yost, N4LI, Box 94, Route 1, Polkton, North Carolina 28135



Exploded view of the essembly. From left are PL-258 barrel connector, homebrew copper plumbing connector, plastic insulators and retaining ring.



Another view of the homebrew hardline coax connector assembly.



Details of finished connector.

step-by-step instructions

1. Using a hacksaw or tubing cutter, cut off 5/8 inch of the outer conductor of the hardline. Do not cut the foam insulation or center conductor. The half-inch pipe die is now used to cut 5/8 inch of threads on this end of the line. Trim off the exposed foam insulation. The center conductor of the hardline is copper-plated aluminum. When removing the insulation be careful not to cut or scratch the copper plating.

2. The inner conductor and the two plastic insulators must be removed from the PL-258 connector. This is necessary because the high heat required in the next step would melt the insulators. You'll find a retaining ring just on the inside of one end of the connector. Remove this ring with a sharp pointed pick. It takes a little patience but it can be done. After the retaining

ring has been removed, the center conductor and two insulators will easily slide out of the shell.

3. Solder the PL-258 shell or body to the copper fitting. The PL-258 has a shoulder in the center that makes a good fit to the inside of the copper fitting. This shoulder should have about 1/32 inch showing outside the copper fitting when correctly positioned. Be sure the end of the PL-258 that does *not* have the retaining ring groove is inserted into the copper fitting. Use a heavy soldering iron, or preferably a propane torch, to solder the two together.

4. The inner conductor of the hardline is larger than that of a PL-259 connector, which is usually used to connect with a PL-258. It will be necessary to complete the following:

a. Using a 1/4-inch drill bit, ream out one of the PL-258 plastic insulators.

b. Spread the prongs of one end of the PL-258 center conductor so that it will make a snug fit with the center conductor of the hard line. Do not change the other end, as it will later mate with a PL-259 connector.

5. You're now ready to reassemble the PL-258 connector.

a. Insert the small end of the reamed insulator first, followed by the spread prongs of the center conductor. This is followed by the large end of the other insulator.

b. Re-install the retaining ring.

Your connector is now complete.

final remarks

Before installing it on the coax line, here's a suggestion. To prevent chemical reaction of the copper and aluminum use a small amount of joint compound on the threads of the aluminum tubing. Electrical-supply houses carry several brands, as aluminum wire is used in industrial and house wiring. Two brands are listed below:

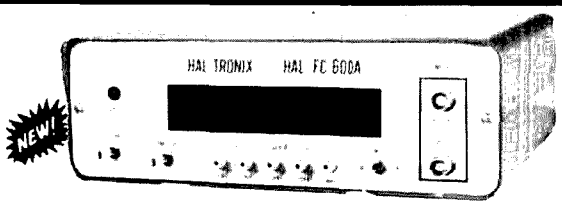
NOALOX — Joint compound for Al/Al and Al/Cu wire connections and aluminum conduit joints. Made by Ideal Industries, Sycamore, Illinois, catalog No. 30-030.

OXIBAN — Oxide-inhibiting compound. Made by ITT Holub Industries, Sycamore, Illinois 60178, catalog No. 15-001.

These or similar compounds are also recommended for use on mating aluminum tubing as used in beam antennas to ensure electrical connection and to prevent seizing.

ham radio

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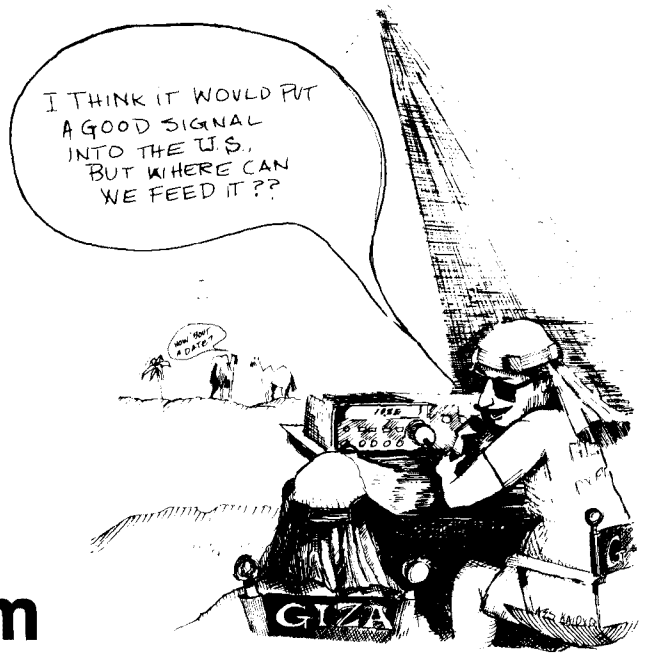
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the K2GNC Giza beam

A novel approach to directional antennas

If you happen to be looking for something simple and inexpensive in a beam antenna, take a look at this one. I haven't determined if this is a new concept, but it may be some time before anyone comes up with a design that performs better. What is it? The Giza beam — a lightweight, low-cost, rugged, directional array that almost anyone can make in an evening from junk-box parts.

I've tried just about every beam over the past 45 years. The design shown in **fig. 1** is easy to build and erect and provides plenty of punch. It's a modification of the conventional delta-loop wire beam (**fig. 2**).

In the Giza design, I removed the upper boom (**fig. 2**) and brought the apexes of the two loops together, which I fastened to the top of the supporting mast. There was no obvious difference in the antenna's operation. Front-to-back ratio seemed the same, it tuned up just as well, and the signal reports remained good. One major structural member had been removed and a more rigid, lighter-weight array with a lower center-of-gravity resulted. Its pyramidal shape and firm, solid construction reminded me of the great pyramids of Giza in Egypt, so it seemed appropriate to name it the K2GNC Giza beam.

a practical 15-meter beam

A bit of shopping brought together all the parts for a functional 15-meter Giza beam. I bought two straight, knot-free, furring strips for about $1.00. I used some No. 18 (1.0-mm) stranded, plastic-covered hookup wire for the elements. Lightweight TV mast sections provided the main supporting member. A few hose clamps, a scrap piece of plywood, and a few miscellaneous small items rounded out the bill of materials.

construction

Fig. 1 shows construction details with dimensions given for 10-, 15-, and 20-meter beams.

Making the four wooden spreaders, the main structural members, requires the most consideration. These were ripped from the two furring strips as shown in **fig. 3**. Painting or varnishing the wood will help preserve its shape and give it a professional appearance. The spreaders may be made of many

By William Pfaff, K2GNC, Box 41, Moriches, New York 11955

materials, including bamboo, fiberglass, metal tubing, or thin plastic pipe.

The mounting plate (**fig. 4**) for the spreaders was made from exterior-grade plywood. It can be any convenient size, or you can use dimensions shown (**fig. 4**). Drill or saw a hole into the center slightly larger than the mast you're using, then drill some holes through it at the proper places for the spreader hinge wires. Any stiff, strong wire may be used for the hinges; there are no strong mechanical forces on them. (A heavy wire coat-hanger is a good choice.)

To assemble, lay the parts out flat. Run short lengths of the hinge wire into the spreader holes, bend them, run them through the holes in the mounting plate, then twist the ends together to hold them in place.

Mount the four corner braces on the top and bottom of the spreader mounting plate using bolts, lock washers, and nuts. Space the braces so that the vertical mast fits snugly between them.

Wrap lengths of stiff, insulated wire around the tip of each spreader and twist together tightly, leaving the ends pointing upward. These wires will hold the corners of the triangular loops.

The spacer cords (**fig. 1**) are lengths of nylon cord or fish line tied securely between the spreader tips. They should separate the lower sides of the loops by the distance shown. To form the loops, cut two lengths of plastic-covered, stranded hookup wire to the length shown in the table of dimensions in **fig. 1**.

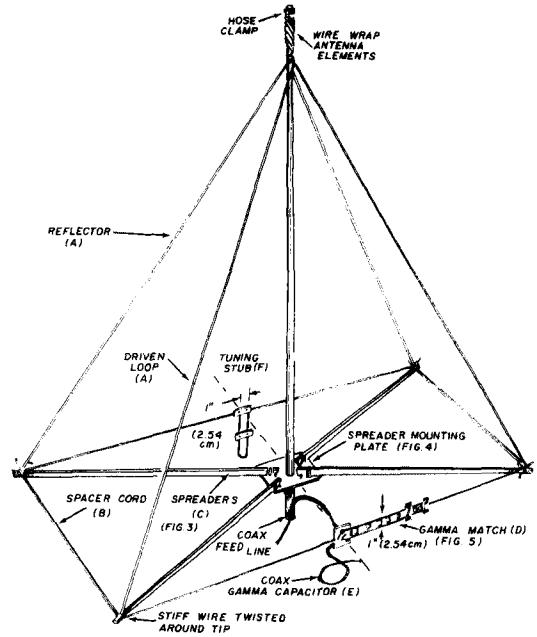
You don't have to use insulated wire for the loops. Bare wire, if used, need only be insulated at the spreader tips where the voltage is high. I used plastic-covered hookup wire because it's readily available, quite strong, and doesn't kink during assembly. Mark the *exact* center of both loops.

matching section

The gamma match (**fig. 5**) can be made from a length of 450-ohm line or two lengths of bare No. 16 wire. A variable capacitor is usually used for adjusting the match to the feed line. However, there's an old trick of using a length of RG-58/U or RG-59/U coax in its place because it's convenient and doesn't require a waterproof housing. These cables provide capacitances of about 30 pF and 20 pF per foot respectively. They will withstand full legal power at this low-voltage point. In fact, for low-power use, it may be more convenient to use two- or three-wire shielded microphone cable, which has a greater capacitance.

Connect the inner conductors together at the end and use them for one side of the capacitor. The shield is the other side.

Remove a length of wire from the end of one loop and replace it with the gamma match section of that



Amateur band, meters	loop length A, ft (meters)	spacing B, ft (meters)	spreader length C, ft (meters)	gamma match D, inches (cm)	gamma capacitor E,* inches (cm)	stub length F, inches (cm)
10	35.8 (10.8)	4.5 (1.37)	8 (1.83)	24 (60)	28 (70)	10 (25)
15	47.0 (14.3)	8.0 (1.83)	8.0 (2.44)	32 (80)	38 (80)	18 (40)
20	71.8 (21.9)	8.0 (2.74)	12.0 (3.66)	48 (120)	48 (120)	28 (70)

*Length of RG-58/U coax cable before trimming.

fig. 1. Design of the Giza beam with dimensions for the three high-frequency bands. Simplicity and readily available parts make this antenna a definite candidate for the homebrewer.

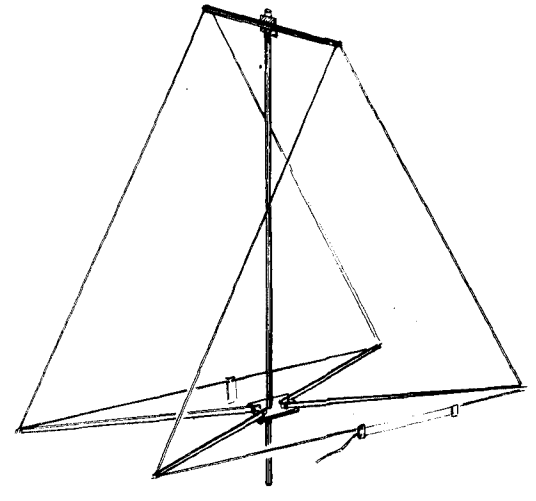


fig. 2. The conventional delta-loop wire beam. The top boom is eliminated in the Giza design, which results in a more rigid structure.

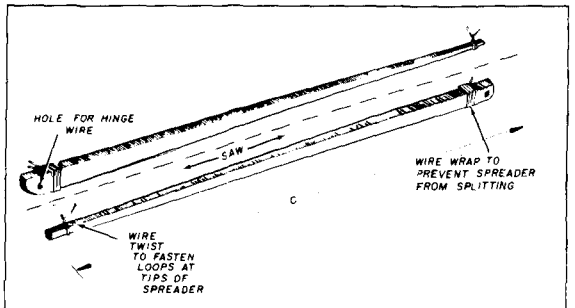


fig. 3. Two spreaders are made from one furring strip.

length. Attach the loop ends to the appropriate plastic insulator of the gamma match and the tuning stub. Secure the lower sides of the two loops loosely to the spreader tips with the stiff wires on each tip. Meanwhile keep the insulators centered and the two lengths equal. Pull the wires taut so that no slack exists in the spacer cords, then firmly twist the stiff wire so that the loop wires will not slip through.

final assembly

Secure the midpoint of each loop to the mast top with a hose clamp and place the mast in the center hole of the mounting plate. It doesn't matter whether the wire is actually grounded to the mast or not. Allow the spreader assembly to fall into a place on the mast where the spreaders are horizontal. Use hose clamps around the corner braces and tighten the mounting plate to the mast. Your Giza beam is now assembled.

tune up

The array is tuned in the conventional manner. However, I suggest that it be tuned to the low-frequency end of the band first for reasons to be explained.

First, adjust the reflector stub for best front-to-back ratio using your receiver and a strong, distant signal. Then position the gamma match slider to a point that provides lowest SWR. Once this point is found, adjust the gamma coax capacitor by snipping off short lengths from its end. At the same time, readjust the gamma match slider. An SWR near 1:1 should be easily obtained.

To prevent the coax from shorting at the end, remove a very short length of the outer insulation and the shield; then seal both ends of the coax with rubber cement, or tape them tightly to prevent water from creeping into the shield. Attach your coax feed line and you're ready to go on the air at the low end of the band.

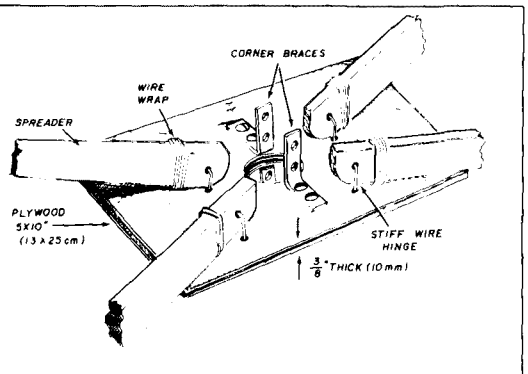


fig. 4. Details of the spreader mounting plate.

a new twist

When it comes to peaking the antenna at a specific frequency in the band, the K2GNC Giza beam has no equal. This operation was discovered by mistake: Once, while making some adjustments, the resonant frequency mysteriously shifted a considerable amount. After some investigation I observed that the spreader section had twisted around the mast while the mast stood still. This action caused the wire at the top of both loops to wrap around the mast. The loop lengths had shortened, thus increasing the resonant frequency. The SWR held at 1:1.

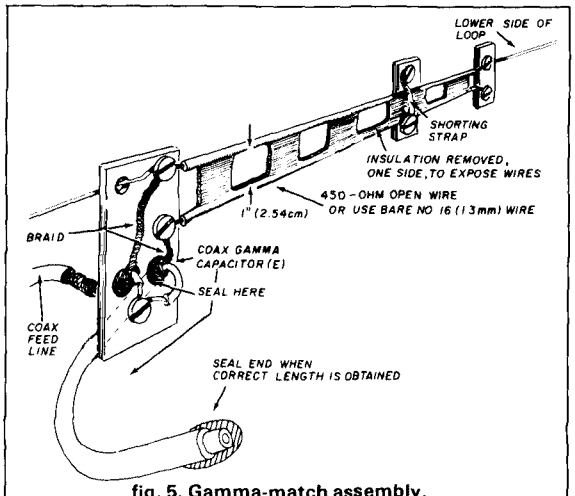


fig. 5. Gamma-match assembly.

Wrap the wires around the pole by twisting the spreader assembly under controlled conditions. I tried it and got just what I wanted — an antenna that can be set mechanically to any desired frequency in the band.

Loosen the hose clamps on the spreader mounting plate and, with the transmitter on the desired frequency, rotate the spreader assembly until you get 1:1 SWR.

Once you've made one of these little giants and tried it out, you'll want to try some variations. A number of them are obvious. Wrapping the apex of the loops around the pole is only one way of accomplishing a resonant-frequency shift. The loop wires could be pulled down into the mast pole by a wire going up through the pole. They could be fastened to a yoke and pulled through a ring at the top of the mast down the outside of the mast. Combining these ideas with flexible spreaders or ones that are hinged at the central mounting plate could bring about some broad frequency variations. You may even encompass another band, especially one of the newly acquired bands.

A triband Giza would give many pluses. Using the usual feed methods for three-band quads, a few additional loops going from the mast to appropriate places on the spreaders would result in a more rigid structure than a single bander. A two-band model, already constructed, has proved this to be true.

A super lightweight, 20-meter Giza has been built using element-size aluminum for the mast and thin-walled, small-diameter aluminum tubing for the spreaders. These spreaders were tipped with lengths of plastic rod and insulated from each other. The mast, in this case, extended far enough below the spreader mounting plate for thin nylon rope guys to be run between it and the tips of the spreaders. This design resulted in an extra strong array that has withstood some pretty heavy winds. Mounting the antenna on the rotor was easy.

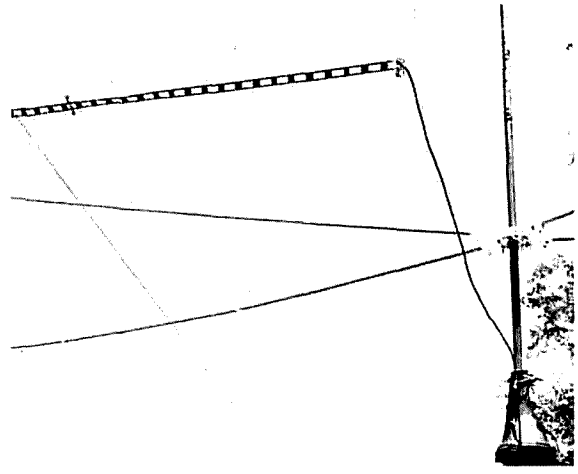
For portable operation or Field Day, what else but a Giza, pre-assembled, folded up umbrella-fashion, and stowed in the trunk or on the car roof? Be watchful that the loop wires don't get tangled with each other. (Perhaps it will help to first check with your nearest skydiver friend on how he packs a parachute.)

The small size and light construction should encourage more beams for 40, 80, and who knows, 160 meters. The same is true regarding the new bands when they become available.

Those who shy away from mounting a big Yagi on the roof because of the wife or the neighbors, or who otherwise want to be inconspicuous as hams, can use No. 22 electric fence wire for the loops. With almost invisible wires, the Giza looks like an fm ground plane to the untrained eye. (Don't ask me who ever saw a ground plane with a rotor on it.)

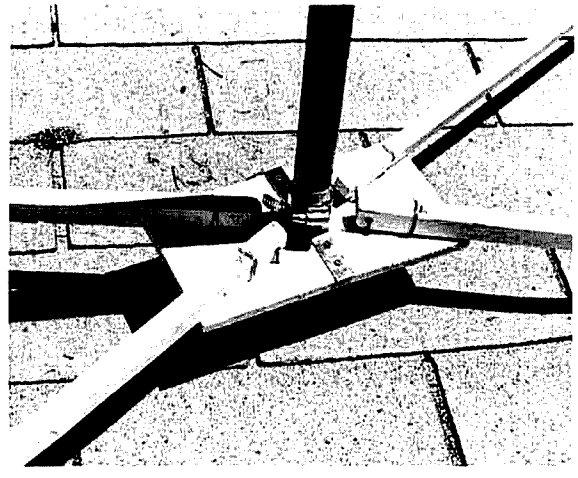
does it work?

So far, the simple construction and light weight of the antenna have been extolled. Now, what happens when rf goes into it? How does it work? There is an inclination to reply, "Try it, you'll like it." However, that answer will not satisfy many.

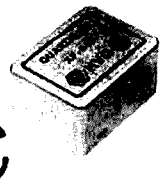


Twenty-meter Giza beam uses 450-ohm, parallel wire line for gamma match. Insulation is stripped from one side of line at *left end of line for* adjustable shorting strap. Microphone cable at feed line input terminal serves as gamma capacitor. Nylon guy lines from aluminum spreader tips to rotor make structure rigid.

Without an accurate means of measuring forward gain, one way to determine performance is to get front-to-back readings. So, with the 20-meter array at a height of only 30 feet (9 meters), readings were gathered from many sources both in the U.S. and foreign countries. The readings averaged around 30 dB. Some readings went as high as 35 dB. Off the sides the reports were about 35 dB lower than off the front. One report said the signal disappeared off both the side and the back when it was 35 dB on the front.



Stiff wire hinges secure spreaders to central spreader mounting plate. Corner braces and hose clamps fasten mounting plate to vertical pole. Wire wraps on spreaders prevent wood from splitting.



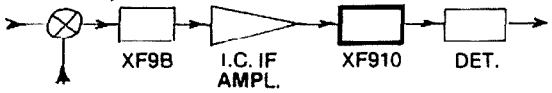
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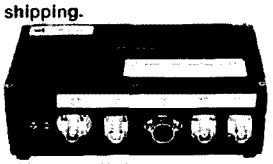
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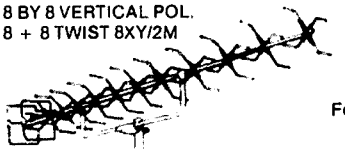


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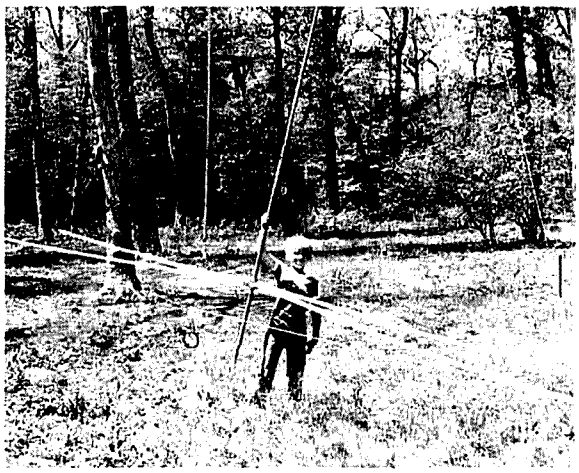
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This all compares favorably with most other good, normal-sized beams. It is probably better than other beams when they are operating off their resonant frequency.

Performance off the front made my heart leap many times. Signal reports rarely, if ever, have any real technical merit, so to say that RST 599 or 599FB was a common report from DX stations is insignificant. However, using the Giza on 20 meter phone has, for the first time, given me 100 percent contacts one time after another, and 20 meters is where you separate the men beams from the boy beams.



Author's second-generation harmonic, Brett, shows off lightweight (7-1/2-pound, 3.4-kg), sturdy construction of 15-meter Giza beam.

Running barefoot with a beam at 30 feet (9 meters) just cannot, of course, compare with the real professional, uppercrust gang and their five elements at 150 feet (46 meters). But when this antenna gets its dander up in the air, fully charged with a linear, it should hold its own with any array of comparable size.

conclusion

There is still much work to be done. What happens when you change the spacing between elements? What is optimum? Can a third or fourth element be added? This remains to be seen. But at this station it is very unlikely that I will ever go back to making a quad, Yagi, or conventional delta loop again. This one does the job so much more easily.

Thanks to my ever-loving wife, Roz, who has put up with a yard full of wires and poles these many years of our happy married life. Also, thanks to all those hams who gave reports at various headings, and my daughter, Lee, who so willingly typed this article.

ham radio

Questions and Answers

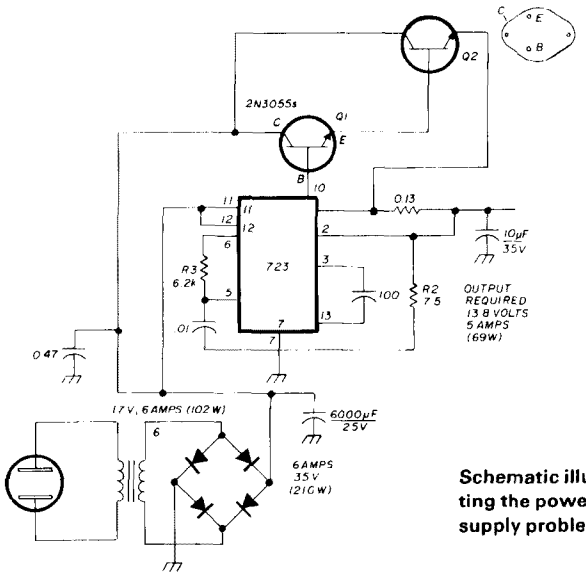
Entries must be by letter or post card *only. No telephone requests will be accepted. All entries will be acknowledged when received. Those judged to be most informative to the most Amateurs will be published. Questions must relate to Amateur Radio.*

Readers are invited to send a card with the question they feel is most useful that appears in each issue. Each month's winner will receive a prize. We will give a prize for the most popular question of the year. In the case of two or more questions on the same subject, the one arriving the earliest will be used.

power supply regulation

I need some insight on why the output of the regulator shown in the schematic diagram does not function properly. John R. Pape, KA2FJA.

The regulator circuit looks OK, but you may be asking too much from the power transformer. According to your schematic diagram, it is rated at 17 volts at 6 amperes (102 watts) input, but it is asked to deliver 5 amperes at 35 volts (175 watts) out. To overcome this problem, change the rectifier circuit from bridge to full-wave. This will provide you with 17.5 volts at 5 amps (87.5 watts) output. Of this, 69 watts will be delivered to the load, while 18.5 watts will be dissipated as heat. The load on the transformer will now be within its rating. Of course, you will need a transformer with a center-tapped secondary.



Schematic illustrating the power-supply problem.

soldering RG-8 to a PL-259

How do you get a decent solder connection to RG-8 braid when installing a PL-259? James T. Petersen, WDØGYD.

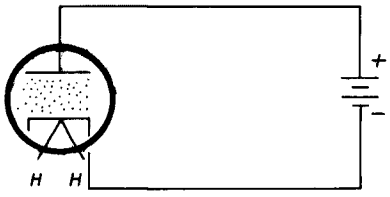
There is a step-by-step procedure for assembling PL-259 fittings to RG-8 cable on page 17-11 of the 1981 edition of the ARRL *Handbook*. Note that soldering of the braid to the plug, or tinning, is the last step in the procedure; even though the dielectric material may soften, it should not run out or be deformed because it is held in place by the body of the assembly.

Another excellent source is *Practical Antennas for the Radio Amateur*, by Robert M. Meyers, W1XT, published by Scelbi Publications. Both books are available from Ham Radio's Bookstore, Greenville, NH 03048.

current flow

Could you explain how it is possible that electrons flow from negative to positive but conventional current flow is from positive to negative? Fred Nordstrom, KA4IZK.

As a matter of convention, when we discuss electric current flow, we always show the direction in which a *positive* charge would flow. Electrons always flow in the opposite direction. For example, in a vacuum tube circuit, as shown here, electrons are boiled out of the cathode and are attracted to the positive plate. By convention, however, we indicate the direction of current flow with an arrow which points in the direction opposite to the flow of electrons.



It is interesting to note that in an electrolytic cell or battery, electrons accumulate on the negative terminal because of a chemical reaction. If then, an external conducting circuit connects the negative with the positive terminal, electrons will flow from the negative to the positive terminal over the external circuit. By convention, we indicate this "current" flow by an arrow pointing from the positive to the negative battery terminals. Confusing, isn't it?

PEP input and output

What is the easiest, most appropriate and least expensive method for determining input and output power in dc or PEP watts? David Ruscitti, WA1FRC.

To determine dc input power, all you need do is multiply the PA plate current by the plate voltage with key down or while whistling into the microphone. Determining input and output PEP is not quite so simple. Peak envelope power cannot be measured directly with meters, since meters respond to the average amplitude of the modulation envelope. It has been generally agreed that peak-to-average input power ratios during a modulation peak will be about 2:1 with the average human voice. The FCC allows 2-kW PEP input maximum, assuming the *average* dc input power (as indicated by the meters) does not exceed 1 kW. Thus, if your voice characteristics are such that the peak-to-average dc input power ratio is more than 2:1, you must run less than 1-kW dc input, as measured by the meters, to comply with the FCC regulation.

About the same things can be said for average and PEP *output* powers. If you have access to a well-calibrated rf power meter, you can determine the key-down power output (or average voice output power) of your transmitter in the usual manner, but the PEP output remains as elusive as ever.

If your rig employs ALC or speech processing, the chances are very good that the peak-to-average output power ratio is about 2:1.

two-tone test

Heathkit mentions the two-tone test to check my linear's linearity. My text books mention this test but fail to explain how these tones are generated or what frequencies are used. Would you tell me how this test is performed? George A. Brooks, WA1BUJ.

The 1981 edition of the ARRL *Handbook* includes information on page 12-18 for two-tone testing of SSB transmitters. An audio oscillator provides one of the two tones, while a small amount of carrier unbalance (purposely developed) provides the other tone. Or you can null out the carrier and feed two audio signals into the microphone jack. A two-tone generator is described for this purpose in *ham radio*, April, 1972.*

There are no specific tone frequencies that need to be used, but they should be within the audio passband of the exciter's microphone amplifier circuit. Generally, one tone is adjusted to 800 Hz while the other is set to about 2000 Hz.

*Hank Olson, W6GXN, "Low Distortion Two-Tone Oscillator for SSB Testing," *ham radio*, April, 1972, page 11.

rules of thumb for coils

Is there a general rule of thumb about the number of turns per inch and total number of turns to yield a given inductance? Don Richardson, WB5UIA.

A useful formula for determining the inductance of single-layer solenoids, which is sufficiently accurate for use in the Amateur high-frequency bands, is:

$$L = \frac{r^2 n^2}{9r + 10\ell}$$

where L = inductance (μH)
r = coil radius (inches)
ℓ = coil length (inches)
n = number of turns

Solving for n will give the number of turns:

$$n = \frac{\sqrt{L(9r + 10\ell)}}{r}$$

Once the number of turns is determined for a coil of a given inductance, merely divide n by coil length, ℓ, to obtain the number of turns per inch.

At VHF the formula becomes inaccurate because conductor thickness becomes an appreciable part of the size of the coil and cannot be neglected. The 1981 edition of the ARRL *Handbook* contains a handy graph for determining the inductance of coils wound with no. 12 (2.1 mm) bare wire, 8 turns per inch.

ham radio

a coreless balun

1:1 impedance-matching transformer using RG-8X coaxial cable

What's a balun? What good is it? Why use it? These are questions often heard among Amateurs. *Balun* is an acronym for balanced-to-unbalanced transformer. The balun is used predominantly in rf transmission lines. A balun placed between an unbalanced feedline (such as coax transmission *line) and a balanced antenna (such as a* dipole or Yagi-antenna driven element) will eliminate or reduce antenna currents on the transmission line, which could cause radio-frequency interference (TVI, BCI).

Much controversy exists in Amateur circles concerning the usefulness of the balun. Some Amateurs swear by it. Others swear at it, claiming that the balun is an unnecessary nuisance and expense. Be that as it may, good engineering practice says that a transition between an unbalanced transmission line and a balanced load is, indeed, necessary. We therefore present this article by Roy Lehner, WA2SON, on a coreless balun for Amateur transmission lines. **Editor**

In pursuit of a balun for my new triband Yagi antenna, I found Badger's article[1] informative and encouraging. Attempting to adapt the design principles outlined in his article into a finished transformer was somewhat difficult for several reasons. The RG-141/U (Teflon dielectric) coaxial cable is extremely difficult to obtain and its cost is more than $3.00 per foot. How do I make the connections to the antenna and feedline that are waterproof and electrically sound? How can the finished unit be mounted on a Yagi-antenna boom in a neat and orderly manner? The following article discloses my resolution to these problems.

The coax I chose is the newly introduced RG-8X, a 52-ohm cable that's inexpensive (about 25 cents a

By Roy N. Lehner, WA2SON, 135 Theodore Street, Buffalo, New York 14211

foot) and capable of handling one kW. It is also easy to work with and coils neatly into a 4-inch (100-mm) diameter coil. (The coil diameter should be 15 to 20 times the coax diameter.)[1]

RG-8X cable can't withstand the same electrical stress as RG-141/U, because of its lower power rating. Using a badly mismatched antenna could ruin the RG-8X coax in the same way that coaxial feedlines may be ruined under high SWR conditions. In terms of balun efficiency and performance, both cables are equal and do a superb job — much better than the popular ferrite or air-wound enameled wire baluns on today's market.

construction

The balun consists of two equal windings of RG-8X coax, each 42 to 48 inches (1.07 to 1.22 meters) closewound into a single-layer coil (**fig. 1**). Although the exact length isn't critical, it's important that the two windings be equal in length to preserve electrical balance. Termination points **A-E** can be neatly made through use of No. 10 (M5) machine screws and eye-type wire terminals. Keep the connections as short and direct as possible. By keeping jumper **B-E** on the outside of the housing, the shield side of the input may be readily identified without having to remove the top cover once it is cemented in place (after, of course, the U-bolt is tightened to the supporting antenna boom).

The balun enclosure (**fig. 2**) should not be made of metal because of possible detuning effects on the resonant transformer. A functional and inexpensive container may be fashioned from a 4-inch (100 mm) PVC pipe coupling cut down to 2-1/2 inches (65 mm) long. Alternatively, a short length of acrylic tubing, or even some plastic freezer containers, may be used. In any case, be certain that the housing is watertight and that the top and bottom covers have no gaps, once cemented into place.

Placing the tube on a piece of sandpaper and slowly rotating it will help ensure a flat and even edge. Two 1/8-inch (3-mm) drain holes should be drilled into the housing bottom.

Similar baluns may be constructed for the 160-40 meter bands; however, a longer winding of coax will be required. (See reference 1 for details.) With a little mechanical ingenuity, there's no reason why this type of balun couldn't be used for flat-top wire dipoles, so long as the enclosure is capable of withstanding the stresses imposed.

What more can be said — good balun, good price, good luck! See you in the pileups.

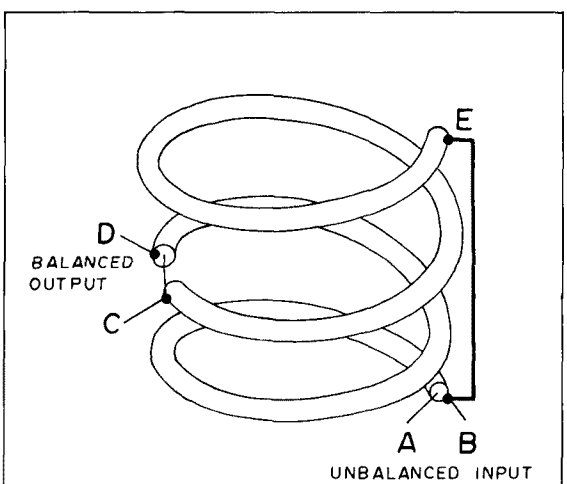


fig. 1. The 1:1 broadband coaxial balun. Actual transformer consists of seven turns closewound (3½ turns either side of the output) of RG-8X coax approximately 4 inches (100 mm) diameter. Center conductor in upper winding is not used.

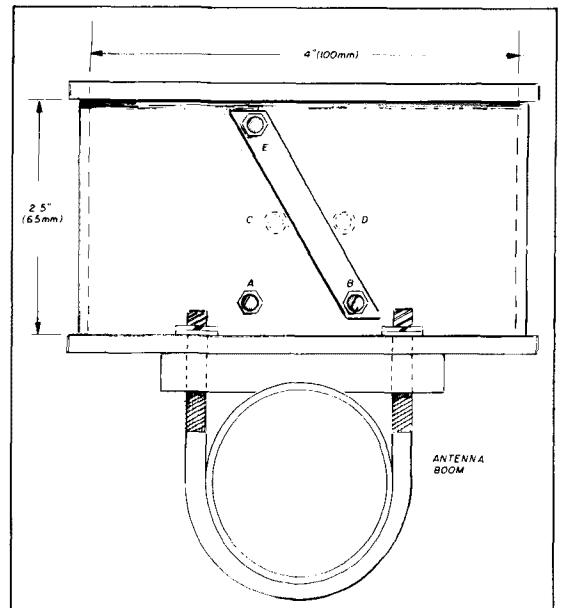


fig. 2. Physical layout of cylindrical balun housing. Output termination points *C* and *D* are located on the opposite side of the container. Top and bottom covers are epoxied in place. *B-E* jumper is mounted on outside of housing to identify shield side of input.

references

1. George Badger, W6TC, "New Class of Coaxial-Line Transformers," *ham radio*, March, 1980, pages 18-29.
2. *Fundamentals of Single-Sideband*, Third Edition, September 15, 1960, Collins Radio Company, Cedar Rapids, Iowa, pages 10-11.

ham radio

low-noise, low-cost 10-60 MHz preamp

Design and construction of a narrow and wideband preamp for the vhf and microwave i-f bands

Amateur bands above 21 MHz offer a challenge for those who like to experiment and build their own equipment. The vhf-to-microwave frequencies allocated to the Amateur service are not overly populated, and this poses a problem. If these bands are not used, we stand a good chance of losing them to other services. Remember what happened to the 11-meter band — we didn't use it, so now it's dominated by Citizen Band users. It's possible that our vhf-microwave bands could suffer the same type of FCC regulation. If we don't use them, we lose them.

This article provides some interesting ideas for the vhf-microwave enthusiast. Are you thinking about adding a preamp to an old 6- or 10-meter receiver? Are you contemplating a low-noise i-f preamp for a microwave mixer with an i-f between about 10-60 MHz but don't want to spend a lot of money for very-low-noise transistors? Read on.

preliminary work

While doing some vhf-preamplifier work, I built and tested several units using the inexpensive NE41632E-2 bipolar transistor. This device (about $3.00 in 1-9 quantities) provided results equal to those obtained about two years ago with a preamplifier[1] using a pair of transistors costing about $16.50!

The results were so impressive that I decided to mount each of a pair of these preamps on two different 10-GHz Gunnplexers.®

®Microwave Associates registered trademark.

By Geoff Krauss, WA2GFP, c/o UHF Electro-specialties, Inc., 16 Riviera Drive, Latham, New York 12110

The preamps described below have either a narrow bandwidth, for single-band units, or a relatively broad bandwidth, which covers 10-60 MHz. The broadband circuit is particularly attractive for a Gunnplexer® i-f preamp because a very-low-noise figure and reasonable gain are obtainable over a bandwidth allowing relatively widely separated i-fs (such as 10.7 and 30 MHz) to be used, with a single preamp attached to a single microwave front end. In fact, the bandwidth-limiting factor appears to be the usable frequency range of the toroidal core used in the output-impedance matching circuit — a core rated for a wider frequency range will broaden the bandwidth range even further.

results?

If you're at all like I am, this is the first question you ask and the first information you look for (**table 1**).

table 1. Comparison of test results for narrowband and broadband preamps.

	narrowband	broadband	
	50-ohm Z_S/Z_L	50-ohm Z_S/Z_L	200-ohm Z_S 50-ohm Z_L
10.7 MHz NF	—	1.57 dB	1.31 dB
G_f	—	15.00 dB	16.30 dB
G_r	—	−44.00 dB	−43.00 dB
30 MHz NF	1.03 dB	1.07 dB	0.94 dB
G_f	23.50 dB (31 dB max G_f)	21.00 dB	25.50 dB
G_r	−34.00 dB	−39.00 dB	−38.00 dB
BW	10.20 MHz	—	—
50 MHz NF	1.07 dB	1.13 dB	0.98 dB
G_f	22.00 dB (30 dB max G_f)	22.00 dB	24.00 dB
G_r	−33.00 dB	−35.00 dB	−32.00 dB
BW	6 MHz	—	—

Note: NF is noise figure. G_f is associated forward gain at the listed NF. G_r is reverse gain. BW is bandwidth, and max G_f is maximum forward gain if tuned without regard for NF.

circuit design

Both narrow and wideband preamps use the common-emitter configuration and an identical bias network (**figs. 1** and **2**). Note that both circuits use some common components (see parts lists). The device emitter is connected to ground through a 100-ohm resistor, R2, bypassed with a 0.01 μF disc cap, C5. A bypassed variable resistor, R1 (1-k pot), is connected to a bypassed 5.1-volt zener, 3-k resistor series circuit. The junction of the pot and zener is dc-connected to the device base, while the end of the 3-k resistor is dc connected to the device collector.

An "idiot" diode, 1N914, 1N4148, or any other small-signal diode rated for at least 15 volts, is in series with a current-limiting resistor, R4. If a 3-k resistor isn't available for R3, a 2.7 k will work as well, although slightly more preamplifier current will be drawn from the B+ supply.

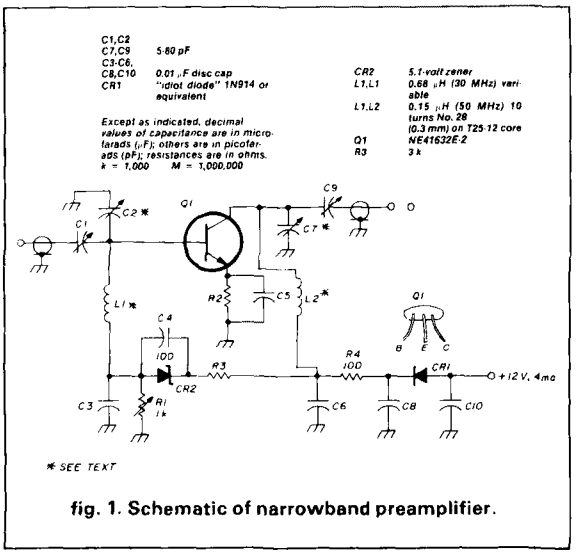


fig. 1. Schematic of narrowband preamplifier.

Resistor R1 sets device collector current for minimum noise figure (or for maximum gain, depending on the desired use). All of the preamplifiers were built on a "universal" single-sided PC board (see **fig. 8**, reference 2).

construction

The preamps were built in general accordance with the schematics of **fig. 1** (narrowband) and **fig. 2** (broadband), with exceptions as noted below.

Narrowband preamp. These units were built according to **fig. 1** except that I didn't use variable caps C2 and C7; instead I used two variable inductors (0.68 μH nominal inductance) for L1 and L2. (For the 50-MHz preamp, **fig. 2**, I used C2 and C7 with toroidal inductors for L1, L2.) This difference in tuned circuits was made because of the parts I had on hand at the time.

The 30-MHz preamp can be built with the toroidal inductor-variable capacitor circuits used in the 50-MHz unit. The adjustment range of C2 and C7 (**fig. 1**) is sufficient for tuning the preamp to either band.

Tuning is accomplished by first adjusting R1 (1-k pot) for about 4 mA of total preamplifier input current from a 10-12 volt dc source. (See **figs. 1** and **2**). If a signal generator isn't available, connect the unit in series with the receiver and tune in a moderately weak signal.

Adjust C1, C2, C7, and C9 (or C1, L1, L2, and C9 if

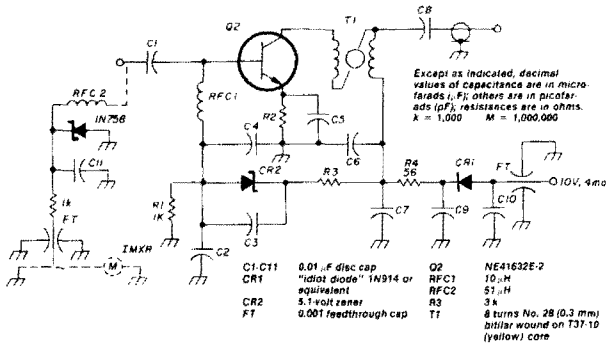


fig. 2. Schematic of wideband preamplifier. Connections also shown for use as a microwave mixer i-f amplifier.

variable inductors are used) to peak the signal on the receiver S meter. Try to use a signal that, even when tuning is complete, doesn't come close to pinning the S meter.

It's advisable to finely tune the preamp by repeating the adjustments several times as they interact somewhat. If a signal generator is available, the signal amplitude can be decreased as the preamplifier is tuned to maintain the receiver S meter at a point approximately *midway* on its scale. Tuning for minimum noise figure can be accomplished by the method of adjusting C1 (and either C2 or L1) for best

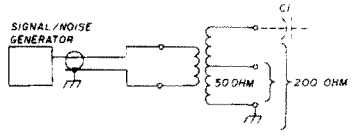


fig. 3. Test setup for a 4:1 input impedance.

signal-to-noise ratio on a *weak* signal. (A noise-figure test setup is preferable, although many can't obtain such equipment.)

Broadband preamp. No tuning components are used. Set R1 for minimum noise figure (about 4 mA total current) or maximum gain, as desired. As shown in **fig. 2**, the unit is designed for a 200-ohm source impedance, which may be provided by the output of a microwave mixer. **Fig. 3** illustrates the input test setup, in which a 4:1 impedance transformer can be used to increase the 50-ohm source impedance of a signal generator, or noise source, to 200 ohms. (I use a Minicircuits Labs T4-1 transformer, but another homebrew transformer can be used instead.) If used in a system requiring a 50-ohm source impedance, permanently connect the second toroidal transformer into the input circuit.

Gunnplexer adaptation

Fig. 4 illustrates one way to mount the i-f preamp to the mixer block, **A**, of a Gunnplexer® microwave front end. Hold block **A** so that you can see into waveguide opening **B**. Note that ferrite circulator rod **C** is to the right, and mixer diode **D** is to the left, of local oscillator injection screw **E**, which runs from the top center of the block in front of the Gunn oscillator iris, **F**.

On the top surface of block **A** are: injection screw **E** (front center), which is held from turning by a nut **I**; the mixer-output post, **G**, to the left and behind

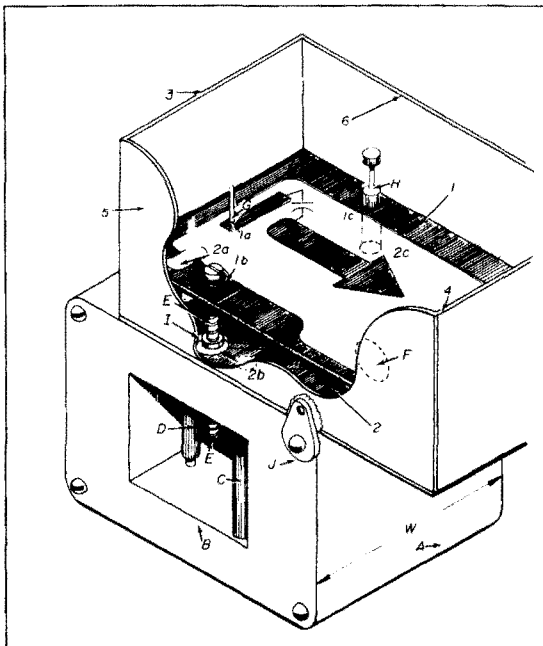


fig. 4. Mechanical mounting details for using the preamp on a Gunnplexer.

screw **E**; and a ground stud, **H**, almost directly behind screw **E**.

Start with the preamp, built on a piece of PC board **1**. (The preamplifier shown is for the universal board of reference 2. The large arrow is the base lead on the board.) This PC board is slightly wider than width **W** of block **A** (**fig. 4**).

Carefully unsolder the leads of the 1-k resistor and zener, which come with the Gunnplexer®, from ground stud **H**; then remove mixer output post **G** (still soldered to the resistor and zener) by pulling *gently* straight up. This post fits over a smaller-diameter pin, which protrudes from the mixer insulator — *be careful not to damage this pin*.

Referring to **fig. 4**, drill a small hole, **1a**, into the PC board at the solder pad at the input end of C1. Align this hole over the mixer pin, now present at location **G**, and mark the PC board with the location for the head of screw **E** and ground stud **H**.

Remove the PC board, and drill hole **1b** to completely clear screw **E** and nut **I**. Drill another hole, **1c**, to clear the head of ground stud **H**. A safe method is to use increasingly greater-diameter drills and check the hole match often by placing the PC board[1] over the top of block **A**. *Do not* touch the setting of, or otherwise attempt to adjust, screw **E** or nut **I**, while fitting the board.

Preamplifier PC board **1** can be mounted directly on top of the block, with mixer output-post **G** soldered through hole **1a** to the C1 pad, and the preamp ground soldered to ground stud **H**. (However, I prefer to place a shield box completely around the preamp.)

I used a piece of unetched PC board, **2**, (single or double sided), which is slightly larger than preamplifier PC board **1** — and drilled three holes: **2a**, **2b**, and **2c** to clear the respective mixer output insulator (a plastic "button" surrounding the mixer pin); nut **I**; and stud **H**. Unetched board **2** is placed right on the top of block **A** and soldered to stud **H**.

A pair of end walls, **3** and **4**, and side walls, **5** and **6**, are soldered to bottom piece **2** to make an open-top box, which will receive preamplifier PC board **1**. Mixer-contact terminal G is permanently soldered in hole **1a** at the input pad of preamplifier PC board **1**.

The PC board is now moved down through the open top of the box, with mixer contact terminal **G** being placed over and surrounding the mixer pin. Screw **E** passes through hole **1b**, and stud **H** passes through hole **1c**. The ground portion of preamp PC board **1** is soldered to stud **H** and is tack-soldered to the inside surfaces of the box side and end walls **3-6**. An rf output connector and **B+** feedthrough capacitor may be soldered through the box walls.

The box is then covered, and the shielded enclosure is complete. This mounting scheme has several important advantages:

1. Full shielding is achieved to minimize i-f interference.

2. Minimum input lead length, between the mixer output and the preamplifier input, is achieved to maintain minimum i-f preamp noise figure.

3. Injection-screw **E** is enclosed and made more tamper proof but is still accessible by removing the preamplifier box top if adjustment should ever be required.

4. Preamplifiers can be changed by untacking the soldered connections of the PC board **1** from the box walls and from ground stud **H** and lifting the preamplifier board out of the box.

I've found that, to provide even *greater* mechanical stability, large ground lugs **J** can be fitted under the screws holding block **A** to Gunn oscillator **C** or to the horn antenna flange, and the lug end(s) can be soldered to the preamplifier shield box.

By connecting the original 1-k resistor and zener (1N758) to the preamp input through RFC_2, as shown by the broken-line connection in **fig. 2**, the dc protection of the mixer diode is maintained, and mixer diode current can be read by placing a 1-mA (full scale) meter from the feedthrough to ground. If a meter is not used, merely ground the feedthrough center pin (on the outside of the preamp shield box). Capacitor C_{11} (**fig. 2**) helps prevent injection of noise from the zener into the preamplifier input.

conclusion

Low-noise preamps may be built for the 10-60 MHz region at low cost, using the NE41632E-2 device. The selection of narrow or broad bandwidth is determined by individual requirements. Similar preamps of either type have been illustrated. I'll be happy to answer any questions if a self-addressed, stamped envelope is enclosed.

Thanks to Jerry Arden, Vice President, Marketing and Sales, at California Electronics Labs* (the NE41632E-2 sales agents in the U.S.) for his interest in providing samples and data.

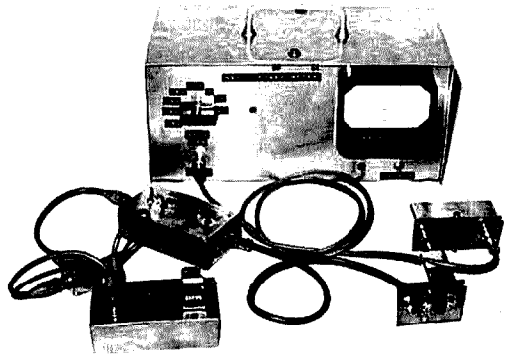
references

1. J.R. Fisk, W1HR, "Low Noise 30-MHz Preampliflier," *ham radio*, October, 1978, pages 38-41.
2. G. Krauss, WA2GFP, "VHF Preamplifiers," *ham radio*, December, 1979, pages 50-59.

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ham radio



rf power meter

part 1 — instrument description and construction

Homebrewing Amateur gear can be an enormously satisfying experience. There's no reward like being able to say "I built it myself." Homebrew gear generally falls into one of two categories: it's either foolproof in construction and can be assembled with a reasonably good chance of having it work the first time you turn it on, or it's complex and needs test instrumentation for calibration and adjustment, which is simply not available to the average ham. This article is devoted to helping satisfy the need for good, accurate measurement instrumentation. This instrument ranks right along with your VOM, scope, and frequency counter in utility.

types of measurements

Frequency and amplitude of rf signals are, fundamentally, the two measurements made. Others are simply variations. Giant strides have been made with the introduction of simple and relatively inexpensive frequency counters priced within the Amateur's budget. Rf power measurements, however, have traditionally been limited to measuring voltage with an rf probe and VOM or a scope. In many cases this simply is not satisfactory due to the limited sensitivity of the instrumentation, or because the measurement is not easily adaptable to this technique.

This article describes an rf power meter that measures absolute power in dBm, 50 ohms, over a frequency range of 3.5-30 MHz. Measurement range, across a 50-ohm load, is between −60 and 20 dBm with an accuracy of ± 1dB.* Armed with a frequency counter and the power meter and accessories described in this article, you can make a variety of scalar network measurements not ordinarily possible without access to sophisticated lab equipment. Best of all, the instrument isn't difficult to build or calibrate. Here are some of the things you can do, just to tickle your imagination, with the power meter and accessories. I have done most of these myself.

1. Evaluate oscillators, QRP transmitters, and small-signal amplifiers with respect to power output, flatness, harmonic distortion, and input return loss (VSWR).

2. Evaluate mixers for flatness, LO and rf suppression and conversion loss or gain.

3. Accurately measure your antenna VSWR down to 1.02 with an uncertainty of ±0.02. It's virtually impossible to get that kind of accuracy and resolution with a simple SWR meter.

*Verified with an HP-8640B signal generator.

By Ralph H. Fowler, N6YC, Route 1, Box 254, Pearl River, Louisiana 70452

4. Simplify filter construction. Synthesis of a 50-ohm LC preselector filter or other bandpass filters, for example, can be a ticklish job. Actual component values can depart considerably from theoretical values due to parts substitutions, tolerance unknowns, and stray capacitances. The power meter, combined with a counter and tunable source, enables alignment and evaluation of LC filters with respect to insertion loss, passband shape (ripple), shape factor, and skirt attenuation (up to 80 dB with a 20-dBm tunable source). If your source is stable enough you can even characterize crystal filters.

5. Adjust interstage and output matching networks (50 ohms). Even your transmatch can be adjusted with the power meter and a directional bridge.

6. Make similar measurements on your kilowatt rock-crusher by adding a simple in-line directional coupler (not described here) to your transmission line. You can, naturally, calibrate the coupler with the power meter.

As an academic exercise you can even measure a-m percentages between 25 and 100 per cent to within a few per cent accuracy. Some of these measurements, plus a few provocative ideas, will be discussed in part 2 of this article.

The power meter consists of three basic parts: a biased Schottky diode *broadband* detector (note the broadband emphasis — this becomes extremely important in the measurements described in part 2), a 37-dB broadband preamp, and a relay-switched 0-70 dB attenuator. These three elements are cascaded as shown in **fig. 1**. Each element is described in turn.

Operation is simple. The step attenuator and preamp set the level of the signal being measured to the proper amplitude for the square-law detector. This is essential since the square-law amplitude range of the detector is relatively limited, typically to between −40 and −10 dBm. Square-law, you may recall, means that the output *voltage* of the detector is proportional to the input *power*. Outside of this −40 to −10 dBm range, the detector does not follow the square-law relationship and will be uncalibrated. Even if the square-law range were greater than 30 dB, it would not be useful in this simple scheme since the meter itself can display only 10 dB of range with acceptable resolution (1 dB) without a logging amplifier included in the circuit. With these complicating factors in mind, I chose to accept a 10-dB measurement range per step of the input attenuator. The only inconvenience is that you have to switch the attenuator to bring the reading within the 10-dB display range of the meter. The meter, incidentally, has a 0 to −10 dB calibration scale. If you can't find a meter calibrated in dB (10 $\log_{10}$) it's easy to add your own calibration marks. A calibration table is shown in fig. **2**.

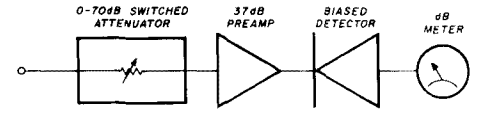


fig. 1. Power meter elements, consisting of broadband detector, broadband preamplifier, and relay-switched attenuator.

the detector

The heart of the power meter is the broadband square-law detector. The original circuit design was described by Wes Hayward, W7ZOI, in *Solid State Design for the Radio Amateur*, and the reader is encouraged to consult this excellent reference for more details. This detector is shown in fig. 3.

Construction is not particularly critical but should be done on PC or copper-clad Vector board to permit operation above 30 MHz, as described later. Leads up to and including the diodes should be kept short. The detector assembly should then be housed inside a compartment or BUD™ box.

The diodes are Schottkys, which are inherently better matched than conventional types and are essential. In addition, these diodes have a better sensitivity than ordinary silicon diodes, thus providing up to −40 dBm sensittivity with careful biasing.

A variety of op-amps were tried in this circuit with good results, including the 741, LM301A, and LM312. Doubtless there are others which would work equally well.

With this design and a little attention paid to short leads at the front end, my unit had a perfect square-law response between −23 dBm and −13 dBm and was virtually flat up to approximately 500 MHz.* An extra 10 dB of sensitivity could have been achieved by calibrating the detector for the −33 dBm to −23 dBm range, but op-amp drift effects began to show up here. Operation between −23 dBm and −13 dBm is drift free.

With this kind of frequency response, it would pay to provide a jumpered detector input on the back panel of the power meter to allow power measurements at vhf and above using the detector alone.

To access the detector (thus bypassing the switched attenuator and preamp, which are much more frequency limited) you could simply remove the jumper coax and plug right into the detector. I don't operate above 30 MHz so I did not include this in my set.

*Compared to a Hewlett-Packard 8640B signal generator as a reference.

dB	percent full scale
0	100
−1	79
−2	63
−3	50
−4	40
−5	32
−6	25
−7	20
−8	16
−9	13
−10	10
−20	1

fig. 2. Data for calibrating the dB meter.

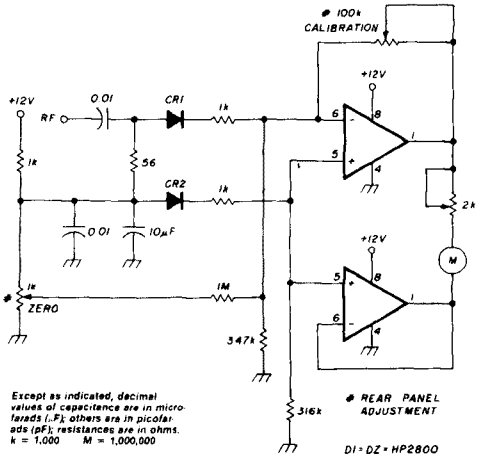
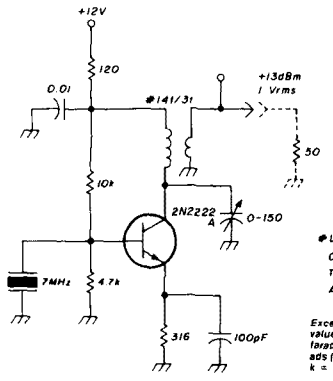


fig. 3. Biased detector schematic. CR1, CR2 are Schottky diodes. Meter is 0-100 microamps or higher. Original circuit was described by Wes Hayward, W7ZOI.

calibration

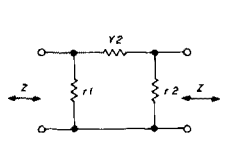
Calibration of the detector is an intermediate step that should be accomplished to ensure that the detector is working properly and to provide a means of measuring the gain of the preamp once it is built. When the power meter is completed, it will then require only minor readjustment to bring it into absolute calibration.

Since the ultimate accuracy of the power meter depends on the reference used to calibrate it, it is crucial that care be taken in its selection. The ideal reference is an accurately calibrated signal generator that can be tuned over the full operating band. Usually this is impractical, so the next best alternative is to simply build a fixed frequency, high-frequency oscillator with an output of about 13 dBm into 50 ohms, corresponding to 1 Vrms. This level is easily measurable with an rf probe and VOM. This oscillator will be used to calibrate the detector and the preamp. **Fig. 4** shows a simple oscillator that will deliver 13 dBm. The relationship between output voltage and power in dBm (50 ohms) is given so that you should be able to compute the exact power output of your oscillator once the rf voltage is measured. Just remember that you must measure the voltage with the output terminated into 50 ohms (a 50-ohm noninductive resistor will do nicely as a temporary load).



Vrms	dBm
0.8	11
0.9	12
1.0	13
1.12	14
1.26	15

fig. 4. Oscillator for calibrating the detector and preamp. Circuit delivers 13 dBm.



ATTENUATOR (dB)	r1 (OHMS)	r2 (OHMS)
1	910	6.2
3	300	18.0
6	150	39.0
10	91	68.0
20	62	240.0
40	51	2500.0

fig. 5. Symmetrical pi attenuator for bringing the 13-dBm oscillator signal into the range of the detector. *Z = 50 ohms resistive.*

The 13-dBm signal must now be attenuated to bring it into the range of the detector. Adding a total of 26 dB of attenuation to the oscillator output supplies the −13 dBm reference required. This reference is chosen since the detector is preceded by a 37-dB preamp, thus giving the desired −50 dBm (full scale) sensitivity. **Fig. 5** shows component values used for constructing the attenuators. Small adjustments to the oscillator collector voltage can also be made for small corrections to output level.

With no input connected to the detector, the zero adjustment should first be set to bring the meter reading to zero. Next connect the −13 dBm refer-

ence signal to the detector and adjust the calibration trimpot to set a full-scale reading. The meter multiplier pot will also have to be adjusted to accommodate your particular meter sensitivity. Disconnect the input signal and reset the zero adjustment. Continue alternating between the zero and calibration pots to complete the initial detector calibration.

To verify square-law operation of the detector, simply add a 3-dB attenuator between the −13 dBm reference signal and the detector input. The meter should indicate half scale, corresponding to 3 dB below full scale or −16 dBm absolute power. Replacing the 3-dB attenuator with a 10-dB attenuator should bring the meter indication to 0.1 of full scale, corresponding to 10-dB below full scale, or −23 dBm. The detector is now absolutely calibrated over the −23 dBm to −13 dBm range and will be used subsequently (along with the attenuators) to calibrate the preamp.

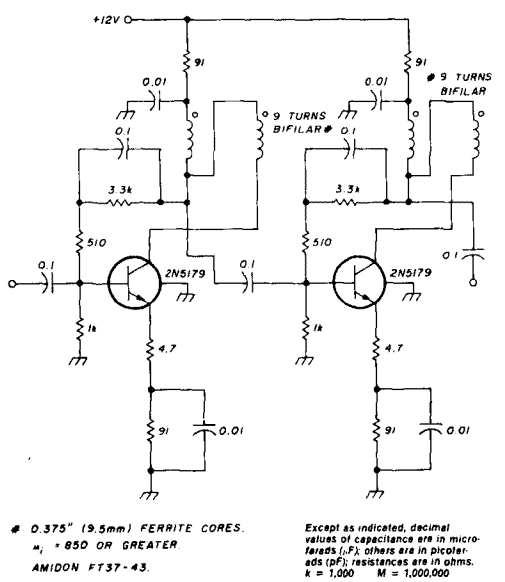


fig. 6. This 37-dB broadband preamplifier is stable, with emitter and shunt feedback. Measured input VSWR is less than 1.2.

preamplifier

The preamp used ahead of the detector supplies 37 dB of amplification using two 2N5179A transistors in a broadband configuration (**fig. 6**). Construction is not critical, and the amplifier should be stable with the emitter and shunt feedback. The feedback also provides a good input impedance match to 50 ohms. Measured input VSWR was better than 1.2. This is important to provide a good match to the step attenuator, which precedes the preamp. If you use another preamp circuit remember not to compromise this parameter.

The broadband transformers should be wound on high-permeability ferrite toroids to ensure the full bandwidth. Using the values shown, the 3-dB bandwidths were 3.0 and 77 MHz, and the 1 dB bandwidths were 3.5 and 37 MHz. Adding a few extra turns should increase the lower 3-dB frequency to allow coverage of the 1.8 MHz band if desired.

Once completed, the preamp should be tested to ensure that 37-dB gain is achieved. More or less gain will require reaccomplishing the detector initial calibration so that the preamp and detector combination have the required −50 dBm full-scale sensitivity. Assuming that the gain is measured to be 37 dB, ± a few dB, this final adjustment can be deferred until the power meter is completed.

To measure preamp gain, construct a 40-dB fixed attenuator and connect it to the −13 dBm reference output. This −53 dBm signal is now applied to the preamp input and the preamp output connected to

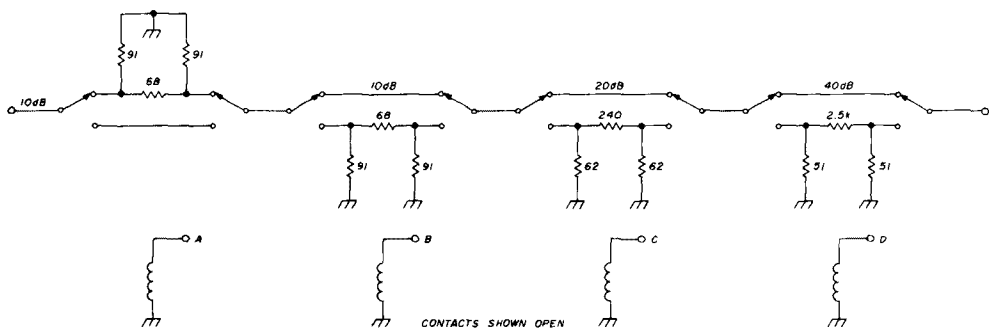


fig. 7. Input attenuator consists of cascaded pi networks. Relays are used here. A better alternative would be the slide-switch circuit in the 1980 *Radio Amateur's Handbook*.

the calibrated detector and meter. The meter should indicate −16 dBm (half scale, assuming full scale is −13 dBm), corresponding to 37 dB of preamp gain.

input attenuator

The switched input attenuator was unquestionably the most difficult part of the project. **Fig. 7** shows the completed unit. A number of prototypes were built with varying degrees of success. The problems encountered most often were (1) flatness variations (a few dB greater than the 1-dB design goal) at the high frequency end of the range, and (2) degraded input-to-output isolation at attenuation levels above 70 dB despite my attempts at shielding. This limits operation of the power meter to 20 dBm (where 70-dB attenuation is used).

As an alternative, you might consider building the attenuator using small slide or toggle switches, perhaps even external to the power meter. Such a unit would have other applications as well as being useful in calibration of the detector and preamp. The 1980 edition of the *Radio Amateur's Handbook* shows construction of a shielded 147-dB step attenuator using simple slide switches; it looks like a good prospect. Using this proven design, you could probably remedy the isolation problems I encountered and increase the measurement range to 30 dBm or higher.

If building the relay-switched attenuator still appeals to you, a couple of construction points are worth remembering:

1. A single-side PC or Vector™ board layout is desirable for minimizing isolation problems and frequency response resulting from impedance mismatches. While the 50-ohm environment of a transmission line is certainly not preserved, I found that by using small PC-mount relays on a Vector board and a physically small layout, an input VSWR less than 1.4 and ± 1 dB flatness up to 30 MHz was attainable, even at the 0 dB attenuation setting (all attenuators switched out). Although not shown in my unit, shielding between attenuator sections would still be good insurance against isolation problems despite my experience.

The resistors used to build the attenuator sections are film type, 1 per cent tolerance, 1/4-watt units mounted close to the relay contacts. Physically small, low-wattage resistors reduce the capacitance to ground and help keep the flatness variations reasonable.

2. The attenuator sections consist of 10-, 10-, 20-, and 40-dB sections switched in as required to provide 0-70 dB of attenuation in 10-dB steps. A 10-dB section is used as the input section and remains switched in at *all times* except at the highest sensitivity setting of the power meter, −50 dBm. This helps establish the good input VSWR and is important when characterizing devices such as 50-ohm LC filters, which require a good 50-ohm termination.

Considering the isolation problems mentioned earlier, measurements at levels above 20 dBm should be done with fixed attenuation ahead of the power meter. Of course, this requires mentally adjusting the readings for the extra attenuation. Remember to construct the external attenuators with higher wattage resistors to dissipate the increased power.

To provide switching the input-attenuator relays, a 4p8t switch or sp8t switch (both make before break) with a diode switching matrix can be used. Since 4p8t switches are not too common, I chose the latter technique. The diode switching matrix is shown in **fig. 8**. The diodes used should be germanium or other low barrier diodes to minimize voltage drops and maintain switching reliability, especially if 5-volt relays are used. If 12-volt or higher relays are used, silicon diodes should be ok.

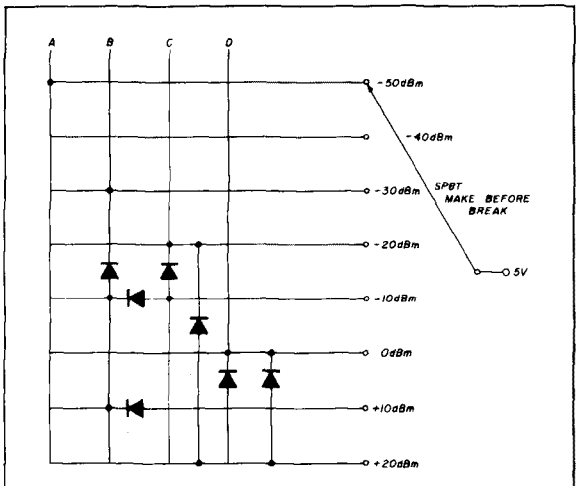


fig. 8. Diode matrix for switching input-attenuator relays. Single pole, 8-throw switch was used.

putting it all together

Once the detector, preamp, and attenuator modules have been constructed, they should be cascaded and the final calibration can be performed. If all goes well, the last step is to mount it all in a suitable box.

Final calibration of the power meter requires simply connecting the −13 dBm reference signal to the input, setting the input attenuator to the −10 dBm full-scale range (corresponding to 40-dB attenuation if an external switched attenuator is used), and tweaking the detector calibration pot to set the meter indication to −13 dBm, or half scale. Power-meter switching accuracy can be verified by using fixed at-

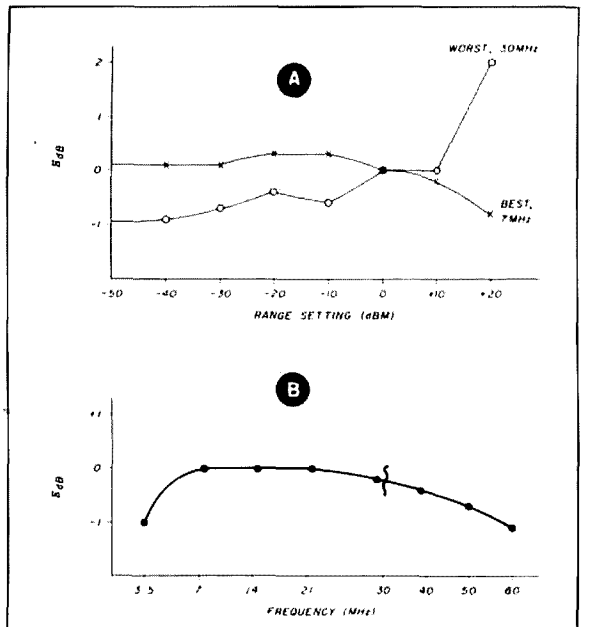


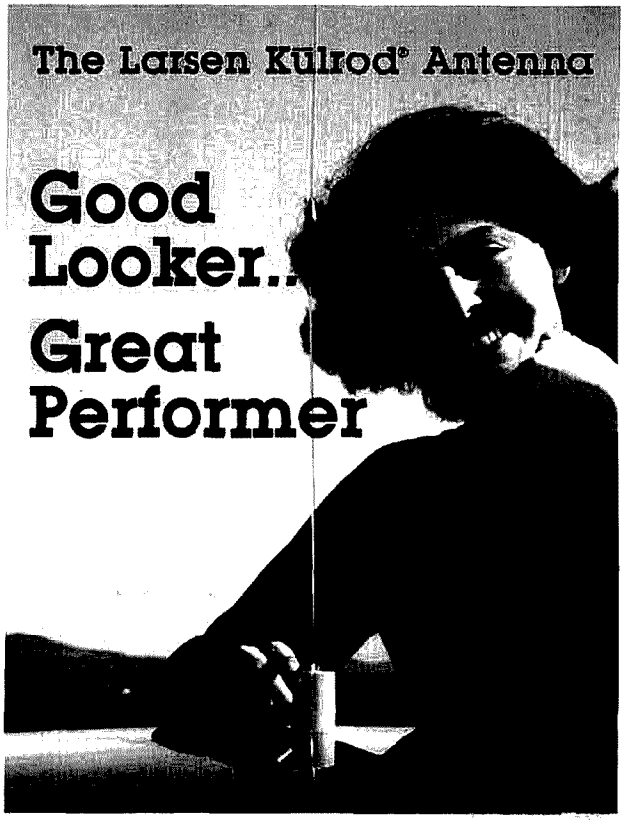
fig. 9. Power-meter step gain accuracy relative to 0 dBm (A) and relative frequency response (B). In-band flatness is less than ±0.1 dB on all bands.

tenuators to attenuate the reference signal and comparing this known level to the power-meter reading. **Fig. 9** shows the flatness and step accuracy that I achieved with my power meter.

Performance testing was done using a Hewlett-Packard 8640B signal generator and fixed attenuators accurate to better than 0.1 dB. Keep in mind that, while you probably won't be able to perform such quantitative performance tests on your power meter, the *in band* flatness could be expected to be no worse than a few tenths of a dB, and the absolute accuracy could reasonably be less than a few dB, assuming the rf probe and VOM used in the detector calibration were accurate to within 10 per cent. Relative amplitude accuracy over the full −60 dBm to 20 dBm range at a fixed frequency should be even better and depends primarily on the precision of the attenuator sections used in the input attenuator. Not bad at all.

The second part of this article will deal with some of the measurements you can make using the power meter. Details of the construction of a return loss bridge, useful for making accurate measurement of low VSWR, and other measurement accessories will be given. We will look at some important measurement considerations aimed at improving the accuracy of your measurements.

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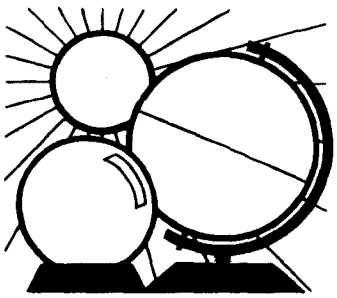
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DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

The first of the month is expected to favor the lower frequencies over the higher bands for nighttime DX activities. DX conditions for the upper-frequency bands should improve during the third week, then round off and drop during the last week. Solar radio flux is expected to be high during that time. Propagation disturbances from solar-flare activity of 2 to 3 days' duration are possible around the 10th and 21st. Conditions will generally be poorer for hearing and working DX during these disturbances, but look for unusual DX locations to appear with weak, fading signals.

The lunar perigee, of interest to moonbounce DXers, will occur on the 4th of this month. An Aquarid meteor shower, of interest to meteor-scatter DXers, will show a maximum between May 4th and 6th, with a rate of 10 and 25 per hour for the North and South Hemispheres respectively.

sporadic-E propagation

One of the major paths for excellent DX signals is short skip, or multiple short skips, in the summer on the higher-frequency bands. The end of May heralds the beginning of the sporadic-E (Es) propagation season. Es is a thin layer of intense ionization about 60 miles (100 km) above the earth. It gives rise to strong, mirror-like signal reflections over the short-skip distance of 600 to 1200 miles (1000 to 2000 km). Signals remain strong from a half hour to a couple of hours on the average, as the name "sporadic" suggests, rather than all day or night as with other high-frequency propagation.

The maximum high frequency propagated by Es follows the sun across the sky; the highest probability of occurrence, however, is near sunrise and again around sunset. These two facets of Es affect short-skip openings differently. Openings on the higher-frequency bands occur near noontime, and the lower bands tend to have openings near sunrise and sunset.

Now look at the best locations for these Es openings: since Es is related to the summer sun, the effect is in the Northern Hemisphere from June on into September and in the Southern Hemisphere during their summer, December through March. The best Es is on either side of the geomagnetic equator; it's especially good where the geomagnetic equator has greatest separation from the geographic equator. These special areas are Southeast Asia in the Northern Hemisphere and South America in the Southern Hemisphere. The first is the best of the two because the E region ionospheric electric currents are strongest there.

To look for Es openings on the higher-frequency bands, monitor beacons on 6, 10, and 15 meters, WWV frequencies, and CB channel 19. Also check TV channels 2 through 5 for 6- and 2-meter openings. The lower bands don't need beacon monitoring, since Es openings (sunrise and sunset) are available most nights. Remember: couple your antenna to the ionosphere with take-off angles of 20-30 degrees (see the January, 1981, *DX Forecaster*).

band by band summary

Six meters will provide very good openings during high solar flux to South Africa, Australia, and New Zealand around local noontime. Look for possible Es short-skip by monitoring TV.

Ten, fifteen and twenty meters will have DX from most areas of the world during daylight and into the evening almost every day, either long skip to 2500 miles (4000 km) or Es short skip to 1200 miles (1920 km) per hop. The length of daylight is now approaching maximum, providing hours of good DXing.

Forty, eighty, and one-sixty meters are the night DXer's band. On many nights 40 meters will be the only usable band because of thunderstorm QRN, but signal strengths via Es short skip may overcome the static when Es is available. Es is not that available in May, although it should be better next month.

Choose the band that will give the best DXing for you at your and their operating times and locations.

ham radio

*Look at next **higher** band for possible openings.

GMT	PDT	MDT	CDT	EDT
0000	5:00	6:00	7:00	8:00
0100	6:00	7:00	8:00	9:00
0200	7:00	8:00	9:00	10:00
0300	8:00	9:00	10:00	11:00
0400	9:00	10:00	11:00	12:00
0500	10:00	11:00	12:00	1:00
0600	11:00	12:00	1:00	2:00
0700	12:00	1:00	2:00	3:00
0800	1:00	2:00	3:00	4:00
0900	2:00	3:00	4:00	5:00
1000	3:00	4:00	5:00	6:00
1100	4:00	5:00	6:00	7:00
1200	5:00	6:00	7:00	8:00
1300	6:00	7:00	8:00	9:00
1400	7:00	8:00	9:00	10:00
1500	8:00	9:00	10:00	11:00
1800	9:00	10:00	11:00	12:00
1700	10:00	11:00	12:00	1:00
1800	11:00	12:00	1:00	2:00
1900	12:00	1:00	2:00	3:00
2000	1:00	2:00	3:00	4:00
2100	2:00	3:00	4:00	5:00
2200	3:00	4:00	5:00	6:00
2300	4:00	5:00	6:00	7:00

WESTERN USA

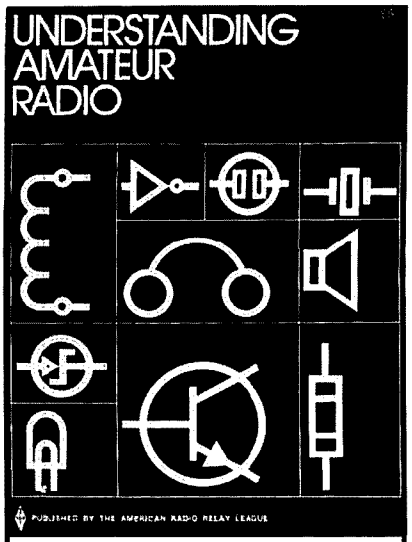
MAY	N ↑	NE ↗	E →	SE ↘	S ↓	SW ↙	W ←	NW ↖
ASIA FAR EAST	--	20	—	15	10	10	10	15
EUROPE	—	20	20	10	10	10	10	15
S. AFRICA	—	20	20	10	15	10	10	15
S. AMERICA	—	20	20	10	15	10	10	15
ANTARCTICA	--	20	40*	15	15	15*	10	15
NEW ZEALAND	—	20	40*	15	15	15*	15*	15
OCEANIA AUSTRALIA	—	20	20	15	20	15	15*	20*
JAPAN	20	20	20	15	20	15	15*	20*
	20	—	20	20	20	15	15	20
	20	--	20	20	20	15	15	20
	20	—	—	20	20	15	15	20
	20	—	—	20	20	20*	15	20
	20	—	—	20	40	20*	20	20
	20	20	20	20	40	20	20	20
	20	20	15	15	40	20	20	20
	20	20	15	15*	40	20	20	20
	15	20*	15	10	—	—	—	20
	15	15	15	10	—	—	—	15
	15	15	15	10	—	—	—	15
	15	15	15	15	—	15*	15	20*
	15	—	15	15*	—	10	10	15
	—	—	—	15	—	10	10	15
	—	20	—	15	—	10	10	15
	—	20	—	15	10	10	10	15

MID USA

MAY	N ↑	NE ↗	E →	SE ↘	S ↓	SW ↙	W ←	NW ↖
ASIA FAR EAST	—	20	15	15*	15	10	10	15
EUROPE	15	20	15	10	15	10	10	15
S. AFRICA	15	20	20*	15*	15	10	10	15
S. AMERICA	15	20	20	15	15	15*	15*	15
ANTARCTICA	—	20	40*	15	15	15	15*	15
NEW ZEALAND	—	20	40*	15	20	15	15	20
OCEANIA AUSTRALIA	—	20	20	20	20	15	15	20
JAPAN	20	20	20	20	20	20	15	20
	20	—	20	20	20	20	15	20
	20	—	20	20	20	20	20	20
	20	—	—	20	40*	20	20	20
	20	—	—	20	40	20	20	20
	20	20	—	15	40	20	20	20
	20	20	15	15	—	20	20	20
	20	20*	15	15	—	20	20	20
	20	15	15	15	—	—	—	20
	20*	15	15	15	—	—	—	20*
	15	15	15	10	—	—	—	15
	15	15	15	10	—	15	—	15
	15	15	15	10	—	15	15	15
	15	15	15	10	—	15	10	—
	—	15	—	10	10	10	10	15
	—	15	—	10	10	10	10	15
	—	20*	—	10	10	10	10	15

EASTERN USA

MAY	N ↑	NE ↗	E →	SE ↘	S ↓	SW ↙	W ←	NW ↖
ASIA FAR EAST	15	20	15	15	20	15*	10	15
EUROPE	15	20	15	15	20	15	10	15
S. AFRICA	—	20	20	15	20	15	15*	20
CARIBBEAN S. AMERICA	—	20	40*	15*	20	15	15	20
ANTARCTICA	—	20	40*	15	20	—	15	—
NEW ZEALAND	20	20	40*	15	20	—	15	—
OCEANIA AUSTRALIA	20	20	40*	20	20	20	15	—
JAPAN	20	20	20	20	20	20	20*	—
	20	20	20	20*	40*	20	20	—
	—	20	20	20	40*	20	20	—
	—	20	—	—	40*	20	20	—
	—	20	—	—	40*	20	20	—
	—	20	—	—	40*	20	20	20
	20	—	15	20	—	20	20	20
	20	15	15	20	—	20	20	20
	20	15	15	10	—	20	20	20*
	20	15	15	10	—	20	—	15
	20*	15	10	10	—	—	—	15
	15	15	10	10	—	—	—	15
	15	15	10	10	—	—	—	15
	15	15	15*	10	15	15	—	15
	—	15	15*	10	15	15*	15	20
	—	15	10	15	15	15*	15	20*
	15	15	10	15	15	15*	15*	15
	15	15	10	15	15	15*	10	15



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ARKANSAS: The Northwest Arkansas A.R.C., Inc. will hold its first annual Hamfest/Swapfest on May 16th at the Siloam Springs Community Building starting at 8:00 AM. Door prizes, exhibitors, free parking and much more. Talk-in on .16/.76 or .52 simplex. More info: S.A.S.E. Bob Harmon, W5SEP, Route 1, Box 13E, Elkings, Arkansas 72727.

CALIFORNIA: 9th annual Sacramento Valley Radio Ham Swap on May 31st from 9:00 - 3:00 at the Machinist's Hall, 3081 Sunrise Blvd., Rancho Cordoval. Food, club auction, prizes, and FREE ADMISSION. Talk-in on K6IS on 144.59/145.19 and 223.18/224.78.

CALIFORNIA: ARRL Pacific Division Convention and 39th annual Fresno Hamfest on May 15th-17th at the Hacienda Inn in Fresno. More info: S.A.S.E. to Fresno Amateur Radio Club, Inc., P.O. Box 783, Fresno, California 93712.

CALIFORNIA: The 1981 International DX Convention at the Airport Holiday Inn, Visalia, California on May 1st-3rd. Hotel reservations via Holiday Inn's toll-free number. More info: N.C.D.X.C., P.O. Box 608, Menlo Park, California 94025.

GEORGIA: 1981 Atlanta HamFestival on June 20th and 21st at the Downtown Marriott Hotel. Second largest crowd in Ham Radio and the fastest growing microcomputer show. More info: S.A.S.E. to Atlanta HamFestival 1981, P.O. Box 27553, Atlanta, Georgia 30327.

IDAHO: The Kootenai Amateur Radio Society's Hamfest '81 on May 9th at the North Idaho Fairgrounds, Coeur D'Alene. Commercial displays, swap tables, food, raffles, prizes, plus more. Talk-in on 146.37/.97.

ILLINOIS: The Six Meter Club's 24th annual Hamfest on June 14th at the Santa Fe Park, 91st and Wolf Rd., Willow Springs. Advanced registration: $1.50 and at the gate: $2.00. Prizes, swapper's row, displays, plus much more. Talk-in on 146.52 or WR9ABC .37/.97 (PL2A). Advanced tickets or more info: S.A.S.E. to Val Hellwig, W9ZWV, 3420 S. 60th Court, Cicero, Illinois 60650.

ILLINOIS: Radio Expo '81 sponsored by the Chicago FM Club will be held, rain or shine, on September 19th and 20th at the Lake County Fair Grounds, routes 45 and 120 in Grayslake. Grayslake is 30 minutes north of Chicago and 45 minutes south of Milwaukee. This year we will have a super large flea market with plenty of indoor and outdoor space, free with a gate ticket. Just bring your own table and chair or tailgate it. Parking is free. We will also have new camping sites complete with power hookups. There will be Ham seminars both Saturday and Sunday. YL's have a ladies program and door prizes both days. Only the best manufacturers of Ham and computer equipment and their distributors will be at our huge display building for you to meet and buy from. As in the past, Expo will be giving out thousands of dollars worth of prizes and admission tickets are good for both days. For advanced registration, send $3.00 per person and a #10 S.A.S.E. to Radio Expo Tickets, P.O. Box 1532, Evanston, Illinois. Tickets at the gate are $4.00 each. Kids under seven are free. For more information call (312) BST-EXPO. Talk-in on 146.16/.76, 146.52, and 222.5/224.10.

KENTUCKY: The Northern Kentucky A.R.C. Ham-O-Rama on May 31st at the Boone County Fairgrounds in Burlington. Flea Market, exhibits, prizes and more. Admission: $4.00, children under 12 free. More info: Ken Miller, WD8ISC, P.O. Box 257, Erlanger, Kentucky 41018.

MAINE: Yankee Radio Club's Yankee Hamfest '81 on June 20th at the Oxford County Fairgrounds in Oxford. Displays, talks, XYL progam, swap tables, Flea Market, exhibitors, prizes and more. Registration: $8.00, complete with dinner and $7.00 for early registration. Admission at gate: $2.50. Talk-in on 146.28/.88 by Don Dean, W1BYK. More info and tickets: S.A.S.E. to Edward Fahey, Jr., 19 Farwell St., Lewiston, ME 04240.

MARYLAND: The Maryland FM Association's annual Hamfest/Computer show on May 31st at the Howard County Fairgrounds in West Friendship from 8:00 to 4:00. Talk-in on 146.16/.76. Admission: $3.00 donation. More info: MFMA, c/o Heru Walmsley, Post Office, Harmans, Maryland (301) 766-3545.

MARYLAND: Fourth annual Frederick Hamfest on June 21st at the Frederick Fairgrounds from 8:00 to 4:00. Free parking, prizes, demonstrations, exhibits, flea market tables and more. Admission: $3.00. YL's and children free. Talk-in on 146.52. Hamfest directors: Rick, N3RO and Peg, N3AIJ, 9425 Glade Ave., Walkersville, Maryland 21793 (301) 898-3233.

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MASSACHUSETTS: The 7th annual Eastern VHF/UHF Conference on May 15th - 17th at the Sheraton Inn Conference Canter, I-495 and Rt. 111, Boxborough. Banquet, technical talks, and many activities of interest to serious VHF experimenters. Preregistration is $13.50 from K1LOG, 3 Pryor Rd., Natick, Massachusetts 01760 before May 10th. Registration at the door is $20.00.

MICHIGAN: The Grand Rapids Spring Swap & Shop presented by the Independent Repeater Association on *June 6th at the National Guard Armory, 44th Street just* 1/4 mile west of US-131. Prizes, dealers, forums, plus much more. Starts at 8:00. Tickets: $2.00. Talk-In on 147.765. More Info: David Jonista, WD8NZZ, 437 Airview S.E., Wyoming, Michigan 49508.

MICHIGAN: The Chelsea Swap and Shop on June 7th at the Chelsea Fairgrounds in Chelsea. Starts at 8:00. Admission: $1.50 in advance and $2.00 at the gate. Children under 12 and non-Ham spouses free. Talk-In on 146.52 simplex and 147.885 Chelsea repeater. More info: William Altenberndt, 3132 Timberlane, Jackson, Michigan 49201.

MICHIGAN: Cadillac's 21st annual "Swap Shop and Eyeball QSO" on May 16th at the Michigan National Guard Armory on Haynes Street in Cadillac. Admission: $2.00. Prizes, tables, displays, and more. Starts at 9:00. Talk-In on 146.37/.97. More info via Wexaukee Amateur Radio Association, Box 163, Cadillac, Michigan 49601.

MICHIGAN: Annual Monroe County Radio Communications Hamfest on June 14th at the Monroe Community College on Raisinville Rd. in Monroe. Tickets: $2.00 at the gate and $1.50 in advance. XYL's and children free. Contests, prizes, free parking, auction, displays and more. Talk-In on 146.13/.73 and .52. Starts at 8:00. More info or advanced tickets: Fred Lux WD8ITZ, P.O. Box 982, Monroe, Michigan 48161 or call (313) 243-1088 Hot Line.

NEW JERSEY: The Tri-County Radio Assocations annual indoor Hamfest/Flea Market on May 3rd at the Passaic Township Youth Center, Valley Rd., in Stirling. Donation: $2.00. Food, prizes and more. Starts at 9:00. Talk-In on 147.855/.255 and 146.52. Table reservations ($5.00) or more info: TCRA, Box 412, Scotch Pines, NJ 07076 or call Herb Klawunn, W2CHA at (201) 647-3461.

NEW JERSEY: The Raritan Valley Club, W2QW, will hold its 10th annual Hamfest and Flea Market on June 20th starting at 8:30 at Columbia Park, Kunellen, NJ. Prizes, food and more. Talk-In on 146.625/.025 W2QW and 146.52 simplex. Tickets: $2.00. Sellers: $3.00. More info call KB2EF at (201) 369-7038 from 9:00 to 4:00.

NEW YORK: The Long Island Mobile A.R.C.'s sponsors ARRL Hamfair '81 at the Islip Speedway in Islip. Over 350 exhibitors, food, awards and much more. Date: May 17th. Heavy rain date: June 7th. Call at night for more info: Sid Wolin K2LJH, (516) 379-2881 or Hank Wener WB2ALW, (516) 484-4322. Talk-In on 146.25/.85. Admission: $2.00. Family members are free.

NEW YORK: The Atlantic Division/New York State Convention combined with the Rochester Hamfest will be on May 15th and 16th at the Monroe County Fairgrounds, Route 15A in Rochester. Commercial exhibitors, huge outdoor Flea Market, FCC exams on Saturday, forums, ladies programs, the *second annual Memorial Code Con*test, prizes, annual banquet, and much much more. Registration: $4.00 in advance and $5.00 at the gate. Tickets: Rochester Hamfest Tickets, 737 Latta Rd., Rochester, NY 14612. More Info: P.O. Box 1368, Rochester, NY 14603 or call (716) 424-1100.

OHIO: The Lancaster and Fairfield County A.R.C.'s annual Hamfest on June 21st at the P & R Part barn, four miles wast of Lancaster off Route 188. Starts at 9:00. Tickets: $2.00 in advance and $3.00 at the gate. Refreshments, Flea Market tables, many activities for the whole family. Talk-In on 147.63/.03 or 146.52. More info: Box #3, Lancaster, Ohio 43130.

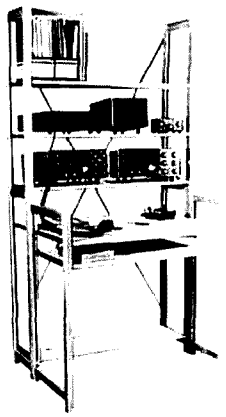
OHIO: The Clinton and Highland County Radio Club's annual Hamfest and Flea Market on June 14th at the Clinton County Fairgrounds on S.R. 22 in Wilmington from 1200 to 2100 UTC. Admission: $3.00. Flea Market space free with admission ticket. Food, auction, prizes and more. Talk-In on 147.72/.12, 147.81/.21, or 146.52. More Info: Bob Lewis KE8E, 192 Northview Rd., Blanchester, Ohio 45107 or (evenings) — (513) 783-2740.

PENNSYLVANIA: Reading Radio Club's third annual Hamfest on May 24th in Hamburg. Starts at 8:00. Cash and equipment prizes, indoor/outdoor facilities, and more. Donation admission. Talk-In on 146.31/.91 and 146.52. More Info: S.A.S.E. to Box 124, Reading, Pennsylvania 19603.

PENNSYLVANIA: The Breeze Shooters 27th annual Hamfest on May 17th from noon to five at the White Swan Park, on Route 60 (Parkway West) near the Greater Pittsburgh International Airport. Large Flea Market, prizes, contest, amusement park, and more. Admission: $2.00 or three for $5.00. Talk-In on 28/.88 repeater or 29.0

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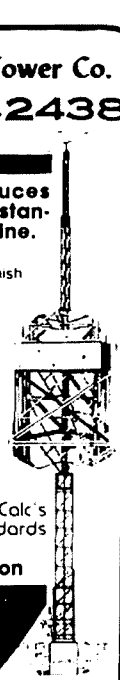
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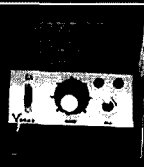
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MHz. More info: S.A.S.E. to Don Myslewski K3CHD, 359 McMahon Road, North Huntingdon, Pennsylvania 15642.

PENNSYLVANIA: MARC's (Milton A.R.C.) 10th annual Hamfest on June 14th at the Allenwood Firemen's Fairgounds on U.S. Route 15, four miles north of Interstate 80. Starts at 8:00. Advanced registration: $2.50 and at the gate: $3.00. XYL's and children free. Flea Market, auction, contests and more. Talk-in on 37/.97 and .52 simplex. More info: Harold C. Dennin AC3Q, c/o Milton A.R.C., P.O. Box 235, Milton, Pennsylvania 17847 (717) 538-5455.

RHODE ISLAND: The Newport County Radio Club's auction on May 18th at the club headquarters (Seamen's Church Institute Bldg., 18 Market Square, Newport) Talk-in on 147.96/.36.

VIRGINIA: The Ole Virginia Hams A.R.C.'s seventh annual Manassas Hamfest on June 7th at the Prince William County Fairgrounds in Manassas (30 miles west of Washington D.C. on Route 234). Exhibits, dealers, food, prizes and much more. More info: S.A.S.E. to Ole Virginia Hams A.R.C., Inc., P.O. Box 1255, Manassas, Virginia 22110.

VIRGINIA: The Lynchburg A.R.C.'s third annual swapfest on May 3rd at the Brookville High School in Lynchburg. Starts at 10:00. Tables, food, free parking, and more. Talk-in on 146.01/.61 and 146.52. More info: Kenneth D. Grimm K4XL, 505 Hayes Dr., Lynchburg, Virginia 24502.

OPERATING EVENTS

"Things to do..."

MAY 3rd: The 50th anniversary of the Reading Radio Club will be celebrated with a special event station (mini-DX-pedition) to Berks County's foremost spot, Virginville. The station W3BN will operate from 1300 UTC to 2200 UTC on May 3rd. Frequencies: 3.950, 7.250, 14.300, 21.400, 29.500, 148.31/.91 phone and 7.125 and 14.045 CW. Special QSL cards available. QSL the RRC direct.

MAY 16th AND 17th: The Blossomland Amateur Radio Association will sponsor a bicentennial expedition to Mackinaw Island during the Michigan QSO party. Operation on 80-10 CW and SSB with 2 meter SSB also planned. Look for W3MAI. S.A.S.E. for special certificate to P.O. Box 175, St. Joseph, Michigan 49085.

MAY 18th: Special Event Station W7AQ. The Yakima A.R.C. will commemorate the "Day The Sun Disappeared" (May 18th, 1980) when Mount St. Helens erupted. Yakima, 80 miles northeast of the volcano, saw the sun disappear by 10:30 and did not see it again until 7:00 the next morning. May 18th was as black as midnight by high noon. Over 600,000 tons of dust covered the city. Commemorate this and W7AQ's 50th year of existence...from 1700 to 0200 hours UTC on May 17th-18th. Listen for W7AQ on 28.660, 21.370, 14.280, 7.285, and 3.940 for SSB. CW will be on 28.120, 21.130, 14.040, 7.140 and 3.740. A special event QSL card will be available. Send a S.A.S.E. to: W7AQ, Yakima A.R.C., P.O. Box 9211, Yakima, Washington 98909.

MAY 31st: The Gabilan A.R.C. will put San Benito County on the air. Times of operation will be from 0800 PDT to 1600 PDT. Times will be extended if activity is good. Frequencies: 28.775 and 21.400 USB and 28.175 and 21.175 slow speed CW. Special certificate and QSL available to those who confirm with a S.A.S.E. QSL to John Kaudet KB6IT, 2001 Scenic Circle, Hollister, California 95023.

JUNE 19th - 21st: The seventh annual Summer Smirk Party Contest from 1900 hours COT the 19th to 1900 hours the 21st or 0000 hours the 20th to 2400 hours the 21st. UTC/GMT/Z. Exchange SMIRK number and State, Province, Prefecture, or Country. Trophy for overall high score. Entries must be submitted on the Fall, 1980 edition of the official SMIRK log. Single copies available for a S.A.S.E. and photocopies may be used. More info or entries: Don Abell WB5SND, 6821 West Ave., San Antonio, Texas 78213.

THE ATLANTA RADIO CLUB announces the third annual competition for two $500 cash scholarships. Each scholarship will go to a licensed amateur entering college in the Fall of 1981. Deadline for completed application is May 31st; request an application from ARC Scholarship, 259 Wetherstone Parkway, Marietta, GA 30067.

AWARD INFORMATION: Revised. The "10-K" and "20-K" award, formerly issued by the CHC is available from KB7SB, P.O. Box 46032, Los Angeles, California 20046. Work 10 (or 20) stations in the outlying territories and possessions with the miscellaneous K calls (KG4, KC6, KP6, etc.). Send log data and #10 S.A.S.E. to KB7SB. Send 3 units postage for return in mailing tube. DX stations send 2 IRC, CPP will supply the envelope. Limited supply.

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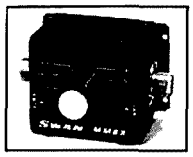
Exclusive heavy duty construction all-band manual switching antenna for 10, 15, 20, 40 and 75 meters. Power rated at 500 watts PEP. Has a patented high-Q tapped coil with GOLD PLATED switch contacts.

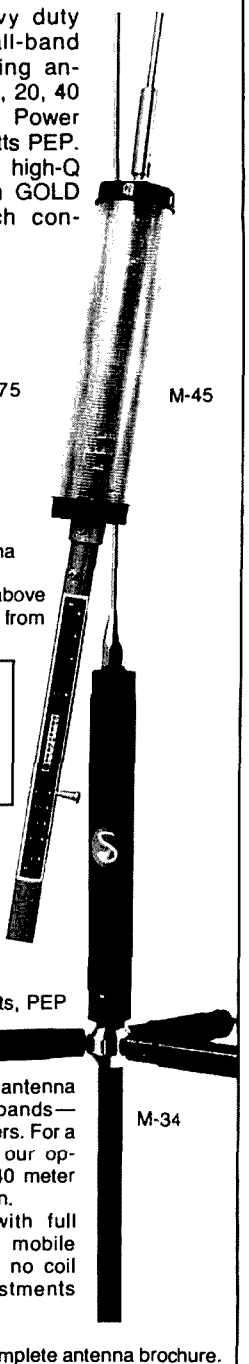
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Switchable Antenna matchbox. Seven impedance ratios above or below 50 ohms from 1.7 to 30 MHz.





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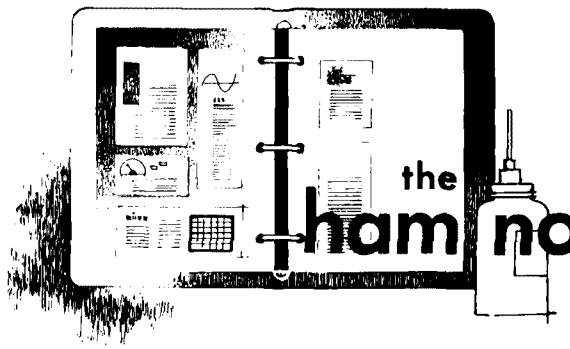
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More Details? CHECK—OFF Page 118



the ham notebook

using a 2-meter quarter-wave whip on 450 MHz

Many Amateurs who enjoy operating 2-meter fm also use a local 450-MHz repeater. One problem facing the dual-band mobile aspirant is placing two separate antennas on the car without jeopardizing its resale value.

Because the best location is the center of the roof and two antennas can't occupy the same place at the same time, I propose the use of a single antenna for both bands. Fortunately, because of the direct third-harmonic relationship between the popular 146-148 MHz and 442-450 MHz repeater sub-bands, a conventional 1/4-wave, 2-meter whip will perform admirably on both bands. At 450 MHz, the whip performs as a 3/4-wave antenna with a 50-ohm impedance. Although the 3/4-wave antenna has a higher angle of radiation than a 5/8 or 1/4 wave, this effect is negligible.

It has been pointed out in the past that a roof-mounted 1/4-wave whip on 2 meters will often outperform a 5/8-wavelength antenna at highway driving speeds because of the way the 5/8 flexes in the wind.

Note that, for best results, the whip should be pruned for best VSWR at the 450-MHz operating frequency.

Peter J. Bertini, K1ZJH

---

aligning Yagi beam elements

a correction

Some essential information was inadvertently omitted from Roy Lehner's article in the January, 1981 issue of *ham radio*. The complete article is presented below. **Editor.**

Assembling beam elements so that they are in line with each other and also parallel to the ground can be a frustrating experience when eyeball or ground-assembly methods are used. The scheme shown in the drawing provides a neat installation in a few minutes and doesn't require any special tools other than a small level. The steps below refer to the numbers in **fig. 1**.

1. Lay boom on concrete blocks or other suitable support.

2. A dummy mast stabilizes the boom structure by virtue of its offset, downward weight and does not permit boom to rotate while performing step **3**. Alignment of mast must be perfectly vertical (see detail A-A), and can be accomplished by sliding mast up or down relative to the boom-to-mast plate. Be sure that this mast rests on firm ground and can't slip through the clamps.

3. Again, using the small level, align the individual elements so they are parallel to the ground. Place the level on top of each element and as close to the boom as possible. A slight downward indication may be noticed due to the weight of the element; in this case, adjust for an equal declination on both sides of the boom.

Roy Lehner, WA2SON

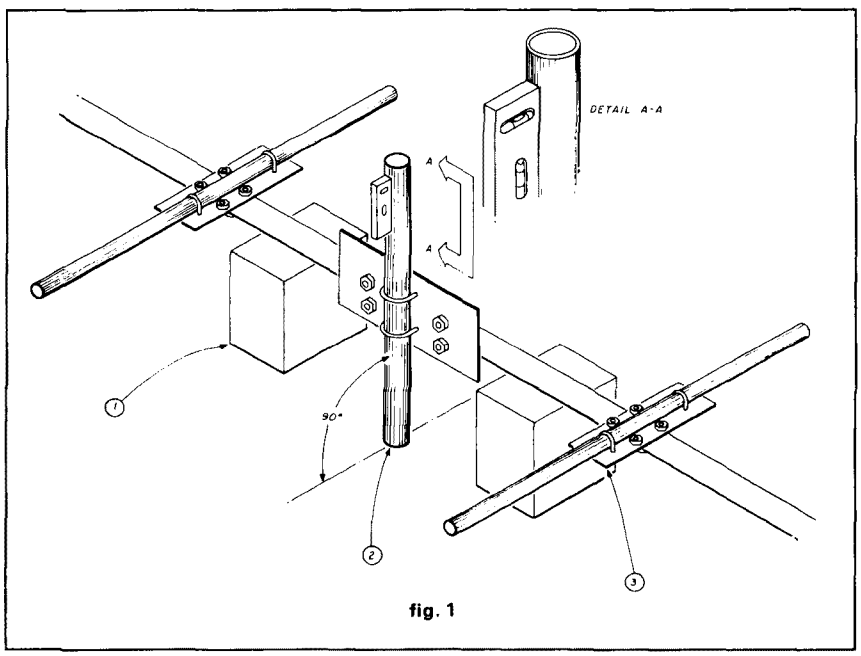


fig. 1

modification of K9LHA 2-meter synthesizer for 144-148 MHz coverage

The 2-meter CMOS frequency synthesizer described in *ham radio* for December, 1979, can be modified for full 2-meter band coverage by making the following modifications:

1. Remove the jumpers on pins 8 and 9 of U1 (CD4059).

2. Change the two high-frequency crystals (Y1 and Y2) to $47.333 - \frac{i \cdot f}{3}$ *MHz* and *47.3333 MHz* respectively.

3. Provide a modified switch code for the MHz range switch as shown below.

4. Increase the VCO tuning range as required by increasing the size of the padding capacitor (C12).

MHz switch code (revised)

A new switch code is needed for the MHz switch for the increased frequency coverage. In addition to pin 10, which is programmed in the existing design, this switch code must be applied to pins 8 and 9, which were previously fixed in programming. A three-pole rotary switch can be used for each MHz range switch, or additional toggle switches can be used to select two coverage ranges: 144-146 and 146-148 MHz. This latter method is probably the simplest and cheapest, although it lacks the simplicity of directly reading frequency that the rotary switches would provide. The new MHz code is as follows:

MHz	pin 8	pin 9	pin 10
144	0	1	0
145	0	1	1
146	1	0	0
147	1	0	1

Tom Cornell, K9LHA

CW memory modification

The November, 1980, issue of *ham radio* had a fine article on a CW memory circuit by Ray Megirian, K4DHC.[1] I assembled the circuit on a perf board and installed it in a 7 × 5 × 4 inch (17.8 by 12.7 by 10 cm) cabinet with an internal power supply.

After I'd become familiar with the unit, I realized that the LED indication of one-half memory remaining during any keyed-in message left something to be desired, since it was too difficult to estimate remaining storage time while keying. Once the balance of memory was overridden, the additional data could not be stored.

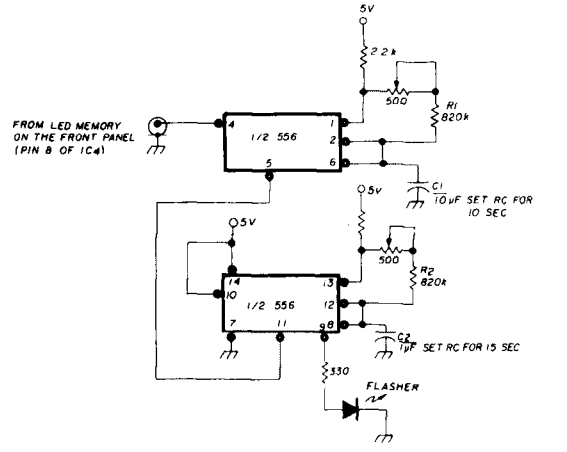


fig. 2. CW memory[1] modification to add delayed second-LED flasher to memory, indicating reserve. One-half of the 556 holds the input high for 10 seconds. The second half is modulated by the first at pin 11 and allowed to flash on/off five times, which leaves approximately 6 seconds of memory storage before the LED light goes out.

circuit

A simple and easy add-on solution was made using the familiar NE555 in the dual 556 package (**fig. 2**). I assembled the circuit on a 2 by 1½ inch (5 by 3.8 cm) piece of perf board.

The one-half LED ON time came to about 20 seconds, as timed by the sweep second hand of my watch. I arbitrarily elected to use a flashing LED display to be set for five flashes and off, after which 5 seconds of storage remained for final keying.

The first section of the 556 was set up as a monostable with its time constant — determined by R1, C1 and the series 820-k resistor — as 10 seconds. The second, or flashing, section of the 556 was set up as an astable free-running oscillator, frequency modulated through pin 11 from pin 5 of the first monostable section. Timing in both cases was set by the miniature 500k pots.

operation

Since the trigger input to the first 556 section is taken directly from pin 8 of IC4 in Merigian's article,[1] timing begins as soon as that LED fires. The new timing (flasher) LED also fires and repeats for four additional flashes, equaling the passing of 15 seconds, after which it extinguishes. The storage LED will remain ON for the remaining 5 seconds of storage time.

You can make your own adjustments as to start and number of flashes with R1, R2. I first considered using only three flashes, in which case the 820k series resistor on R2 should be increased to 1 meg. However, I react only to the halting of the flashing during input keying, so I selected five flashes.

reference

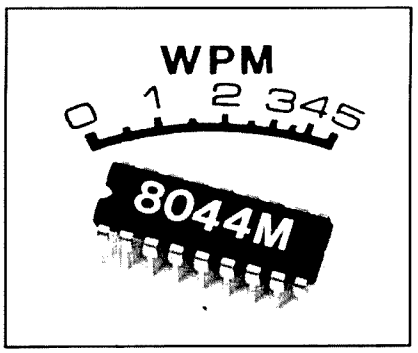
1. Ray Megirian, K4DHC, "Simple CW Memory," *ham radio*, November, 1980, pages 46-47.

Gene Shapiro, WØDLQ

NEW products

Curtis 8044M adds speedmeter output

An enhancement of the popular 8044 CMOS keyer has been introduced by Curtis Electro Devices. Called the 8044M, this new integrated circuit adds an output designed to drive an analog meter for speed indication. Speed indication from 6 WPM to as high as 100 WPM can be accomplished by simply adding two capacitors, a resistor, and a 100-μA meter. The meter indication can be calibrated to be well within a 5 percent tolerance. The reading is stable, even at the lowest speeds.



The addition of two extra pins at the end of the package permits a pin-for-pin fit with the standard 8044. One of the pins is used for a timing capacitor and the other pin drives the meter directly. This allows retrofitting in many existing keyers with relative ease. The keyer function of the 8044M remains the same as in the 8044 design, providing dot and dash memories, iambic operation, key debouncing, weight control, monitor oscillator, and extremely low power dissipation.

Housed in an 18-pin plastic package, the 8044M is priced at $19.95 and is available from Curtis dealers or factory stock. Two kits are available to help in construction of a quality keyer. The 8044M-3 offers the IC, a PCB, edge connector, socket and manual for $29.95. The 8044M-4 is more complete offering all parts except chassis, knobs, jacks, switches, speaker, meter, and power supply. It is priced at $59.95. Various suitable meters are also available and are priced at $7.95. For further information, contact Curtis Electro Devices, Inc., Box 4090, Mountain View, California 94040.

"no-stretch" guys

Lightweight, noncorroding guys offered by Philadelphia Resin Corporation provide significant improvements in tension-elongation properties when compared with galvanized IPS wire strand, GRP rod and Phillystran PS29 (the manufacturer's original flexible, dielectric guys).

The new Phillystran HPTG tower guys are smaller in diameter and lighter than earlier Phillystran guys. Hence, wind resistance has been decreased and there is significantly less surface for ice accumulation. Weather resistance has been further increased by a new extruded olefin, copolymer jacket, which ensures complete protection against ultraviolet degradation.

The termination of factory-assembled, cut-to-length, dielectric guys has been upgraded with an improved potting system. However, the major improvement in Phillystran HPTG is its much lower elongation, not exceeding 0.3 per cent at normal working loads. This extremely low elongation — and the negligible creep of an assembled guying system — significantly decreases tower deflections, while providing riggers with the convenience of tension-once and walk-away installations.

The new dielectric tower guys incorporate all of the advantages provided by Phillystran guys, including the following:

Elimination of white-noise arcing, EMI, and complaints about TV reception near radio-broadcast sites.

Significantly fewer labor hours required to guy a new tower or to reguy an existing tower.

No insulators or painting required.

Resistant to icing and inclement weather.

High strength-to-weight ratio.

No problems with fire. A short, steel lead line is recommended between each ground-level turnbuckle and each flexible, dielectric guy.

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The new MFJ police/fire converter, model MFJ-311, will convert any 2-meter synthesized or VFO rig to cover the VHF-band police and fire frequencies. If your rig covers 144-148 MHz, just insert the MFJ-311 in line with the antenna, connect power, and turn on the converter, now you can receive 154-158 MHz. If your rig covers a larger or smaller section of the band, then with the MFJ-311 you can receive a correspondingly larger or smaller section of the VHF police and fire band. The frequencies between 154 and 158 MHz contain nearly all FCC allocated VHF police/fire activity.

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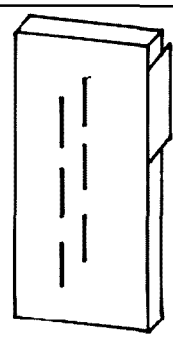
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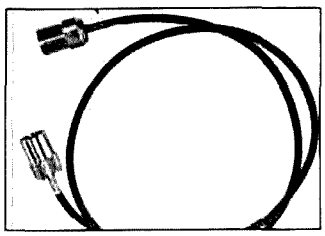
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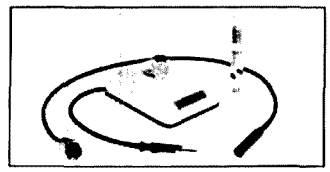
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diode selector guide

Motorola announces its new, free RF Signal-Processing Diodes Selector Guide. The six-page manual lists all Motorola tuning diodes for frequency control, plus hot-carrier diodes for mixing and detection, and PIN diodes for switching.

Included in this handy reference are several useful design curves, package information, and reliability data. To order the RF Signal Processing Diodes Selector Guide, write to Motorola Semiconductor Group, P.O. Box 20912, Phoenix, Arizona 85036.

new Hamtronics® kits

Hamtronics, Inc., has announced a new single-channel UHF fm exciter called the model T451. Patterned after the popular T450 exciter, the new unit is rated at 2 watts continuous output and is contained on a 3 × 5½ inch PC board. It is designed for the 50, 144, and 220 MHz bands and may be modified for use on adja-

cent commercial and government bands. It is ideal for control links, repeater service, telemetry, and other applications for which a small unit is required. A multichannel adapter is also available to extend operation up to five channels.

Features include low-impedance dynamic mike and high level audio inputs; crisp, clear modulation; low spurious output; pre-wound coils; adjustable output level; and built-in test points for easy alignment. A commercial-grade frequency stability option is available. The price of the T451 is only $59.95.

For further information, contact Hamtronics, Inc., 65F Maul Road, Hilton, New York 14468.

lightning protection

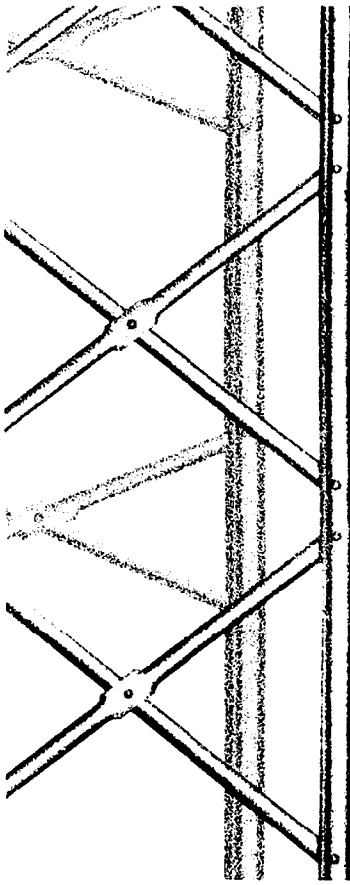
The new Zap Trapper, introduced by PolyPhaser Corporation, significantly outperforms previous lightning protection apparatus for communications antennas, cable, and equipment. The Zap Trapper impulse suppressor utilizes controlled atmospheric technology to ensure a microsecond response to lightning impulses, plus multiple impulse suppression, which is especially critical for the protection of today's solid-state communications equipment. Specifications, type N: bandwidth, 0.1 MHz to 1000 MHz; insertion loss, 0.1 dB maximum at 1000 MHz; VSWR, 1.15:1 at 1000 MHz; impedance, 50 ohms constant.

For more information, contact PolyPhaser Corporation, 1500 West Wind Boulevard, Kissimmee, Florida 32741.

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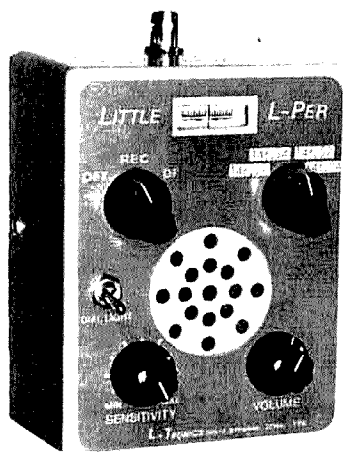
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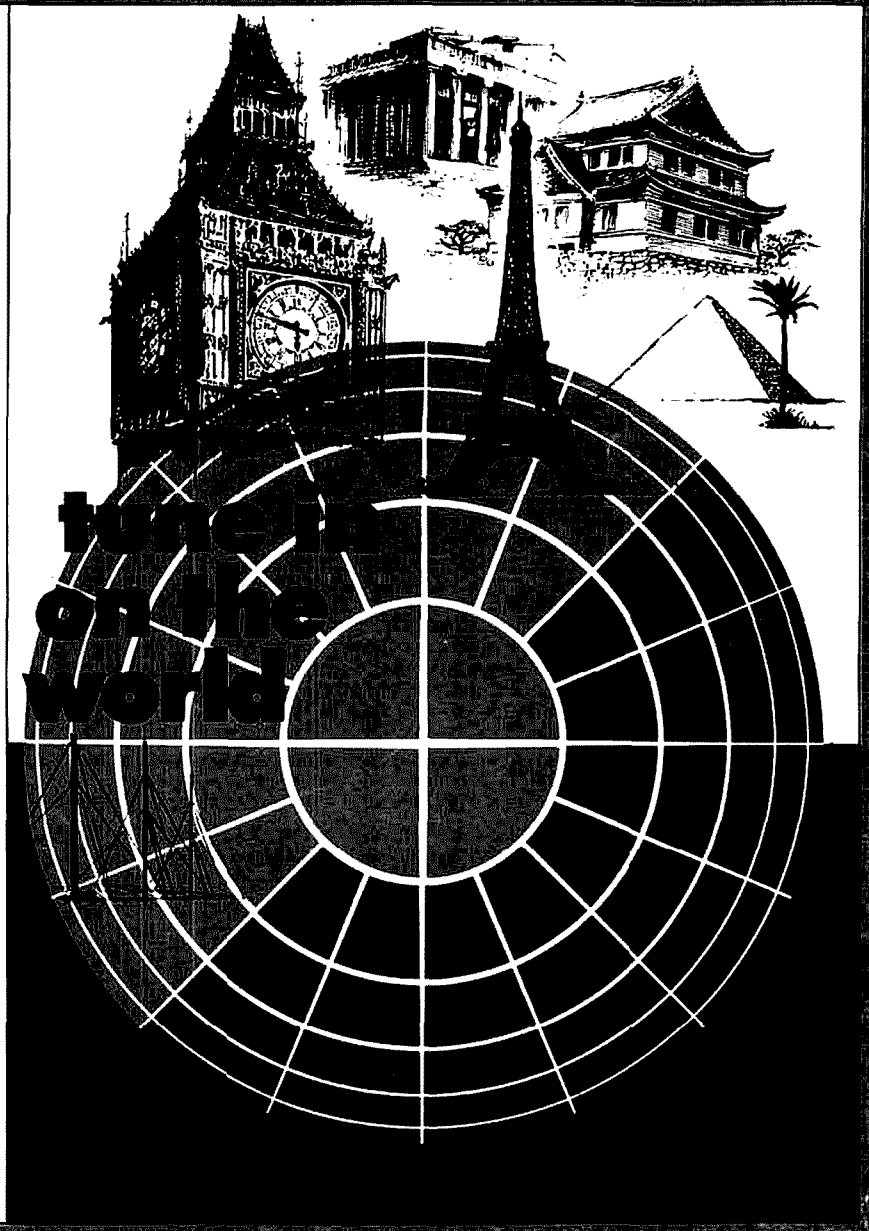
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JUNE 1981

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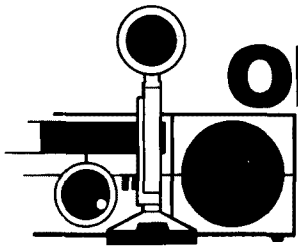
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Observation & Opinion

Have you ever wondered how a magazine works? What makes it tick? I'm not talking about just any magazine — I'm talking about *ham radio*. When you remove the current issue of *ham radio* from your mailbox, you're looking at the culmination of many months of work by a lot of dedicated professionals: editors, graphics specialists, typists, advertising people, circulation people, and many others. It's a team effort, and each member is an expert. Each is responsible in some way for the magazine that you've been waiting for.

It seems to be a fact of life in the magazine business that the advertising and editorial people are extremely competitive. Traditionally, these two camps are at odds. The ad people want X number of ad pages, and the editorial types want Y pages of articles. As the publication deadline approaches, this dilemma can cause problems. The editorial people understand that ads pay the bills, and the ad people understand that, without good articles, the magazine won't work. At *ham radio*, a compromise is struck using cooperation and teamwork. It works.

We've received some complaints that *ham radio* has too much advertising. If you count the pages of ads in any of our issues, you'll find that we're giving you a 50-50 mix of ads to editorial content, regardless of the size of the issue. So if we have a larger magazine, yes there will be more ads, but there will also be more articles.

These articles can't come to you unless there's some way to pay the printing bill. Sure, you pay for a subscription, but that barely begins to cover the cost of putting *ham radio* together every month. We must pay for the articles, the editing, the typesetting, re-editing, paste-up, printer, and postage — not to mention all the overhead costs.

So where does the bulk of the money come from? Advertising. Without advertising, there would be no magazine. ARRL would find itself totally incapable of giving you the membership services it now does without ads in *QST*. The *National Geographic* would probably be printed on newsprint with black and white photos.

As I mentioned earlier, occasionally I find myself at odds with the gang down at advertising. Sometimes they want a special favor for one of their accounts. We editorial types try our best to accommodate the ad people. But sometimes there's something we don't like about an ad, or it's too late to break up that part of the magazine to fit the ad people's needs. In any event, we always manage to get the problem ironed out despite gnashed teeth and upset tempers.

We must be doing something right. While most of the rest of the industry has either decreased the number of ad pages or maintained status quo, the combined *ham radio/HORIZONS* is running about 20 percent ahead of last year in number of ad pages sold. This means that we are able to give you a better value for the dollars you spend for subscriptions.

I felt that this little discussion was important, because some of your letters have indicated that there's something less than complete understanding in the relationship between you, the reader, and our advertising and editorial departments.

Elsewhere in this issue you'll find a very important survey that we'd like you to fill out and return to us. I need it to find out what kind of job I'm doing as editor of *ham radio*. Advertising needs it for demographic studies and readership profiles. It's your chance to voice your opinion. Can we please hear from you?

Alf Wilson, W6NIF
Editor



comments

80-meter receiver

Dear HR:

I have received many calls of congratulations on the experimenter's 80-meter receiver published in the February, 1981, issue of *ham radio*. Here are some suggestions from readers, and a correction.

The change shown in the schematic will give a sharper response and more gain. Experimenters have suggested that J.W. Miller part 12-C30, if properly connected, can replace the 1726 transformer if the latter is not available. Note that pins 4-5 of the 1726 transformer are connected together to make a single-tuned circuit. Also note that the secondary pin 2 is connected directly to pin 1 of the 40673, and a 22k resistor is placed across the coil to ground.

The J.W. Miller coil 4515 mentioned in the article (page 25) is now coil 4514 in their new catalog.

One builder found he got better results by shielding the i-f board; alternatively, it can be mounted on aluminum. The leads should be kept short to prevent broadcast-station pickup.

The power supply (page 26 of the article) shows resistor symbols for the capacitors on each side of the LM340 regulator. These obviously should be capacitor symbols.

Ed Marriner, W6XM
La Jolla, California

electrolytic capacitors

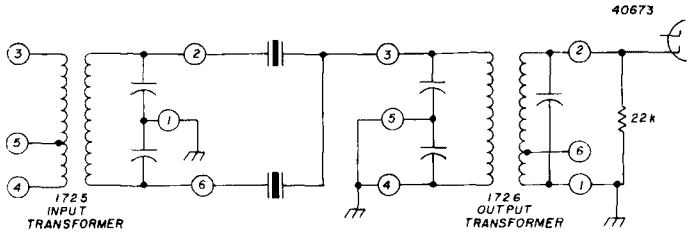
Dear HR:

In reference to the article on capacitance measurements by Hemmye, KP4DIF, on page 24 of the September issue, I think this is a good technique, and it is certainly cheaper than getting a meter to measure capacitance. However, it is most likely to be used on inexpensive surplus capacitors. Because those capacitors are often old and leaky electrically (that is, they allow too much dc to pass through), the technique should be modified. I suggest the following: first, connect a milliammeter in series with the capacitor under test and gradually increase the voltage across the capacitor to near the rated voltage. A variac in the primary circuit, or potentiometer in the secondary, is handy for this.

Remember that the capacitor "looks like" a dead short until it is charged, and without a way to increase the voltage slowly you are likely to damage the meter. After the capacitor is charged, you will see (if the capacitor is not shorted inside) that the leakage current will fall slowly. It will take from a few minutes to an hour for the current to stabilize; leakage current will take longer to stabilize the longer the capacitor has been without a charge on it. Electrolytic capacitors last longer if they are used occasionally.

After the current has become reasonably constant, you should do two things, particularly if the capacitor is surplus. First, figure out how much power is being dissipated in it. If it is much more than a watt or so, throw the capacitor away. Leaky electrolytic capacitors get hot and blow up — you haven't lived until you have cleaned up the mess they make when they go. Next, calculate the leakage or shunt resistance of the capacitor. For example, say you have 300 volts across your capacitor and it is leaking 3 mA. This electrolytic looks like a perfect capacitor in parallel with 100 kilohms. If you're using KP4DIF's technique, it's important that the resistance you put in parallel with this capacitor be low in relation to this 100 kilohms or your results will be off. A good rule of thumb would be to have one tenth or less of the leakage resistance, the less the better, within the constraint of not having the RC combination discharge too fast. You can figure in the leakage resistance if you want, but the matter is complicated by the fact that the leakage resistance is something of a function of the voltage across the capacitor. This is another good reason for the resistance you put in shunt with the cap to "swamp" the leakage resistance.

Eugene W. May, Jr., WB8MKU
Ann Arbor, Michigan



Suggested mods for the 80-meter receiver.

slow ASCII

Dear HR:

Since the long-heralded advent of ASCII on the Amateur bands, there has been a singular absence of its use. Therefore, now that the cheering about FCC approval is over, may I suggest taking another look?

With the sophistication of upper and lower case letters, numerous symbols and commands, one might have anticipated a wide-spread adoption of eight-level ASCII over the older five-level Baudot, which is naturally limited. But instead, the solid-state

comments

segment of the RTTY community (which is increasing as older equipment is replaced) has been notably indifferent, even dismissing ASCII as not suited for the high-frequency bands because of its theoretically greater information loss in QRN. Is it possible that this criticism, though *reasonable, is misplaced,* and the real reason is ASCII's lowest speed begins at 110 baud and is too fast for the "real world" of RTTY where hand-typing at 45 baud predominates and is evidently preferred?

It would be unfortunate not to see this elegant code used as Baudot is now used, despite its origin in computer applications. Therefore, I propose that speeds of 45, 50, and 56 baud be added to those now available for ASCII in future RTTY gear and update mods. "Slow ASCII" can help keep Amateur Radio abreast of computer techniques.

Albert F. Storz, W3FVC
Pottstown, Pennsylvania

computer rfi

Dear **HR**:

I, like many other radio and computer hobbyists, am having trouble with RFI from my TRS-80 computer. I have noticed, however, that when I have my computer turned on, my fifteen-year-old Admiral table model a-m radio with tubes has good audio without any hint of RFI. Yet on the same table the noise level is quite high coming through a new Drake TR7 transceiver and a Bearcat scanner. The old tube radio plays away as if there were no problems. Do you think the old superheterodyne circuitry holds a solution to this perplexing problem? I would be interested in hearing from anyone else with this particular problem or possible solutions.

John J. Watermeier, KA5HJI
New Orleans, Louisiana

Heath HW-2036 mods

Dear **HR:**

I read with interest the HW-2036 modification article by Tom French, WA4BZP, (November, 1980, *ham radio*), but I felt that two things should be brought to your readers' attention.

First, the Heath Company offers a modification for the older Micoder™, HD-1982 models, to convert them to crystal control. This is part number 830-30 and can be ordered from our parts department for $8.95 plus 90 cents postage.

Second, and more noteworthy, we have serviced one HW-2036 with Tom's "2036-MB" board installed. This unit was returned for service because the receiver seemed to drift erratically. In troubleshooting the unit, we noted a very high noise level on the VCO tune line at TP-401, which caused the condition. This noise was traced to the new encoder board. The receiver was stabilized by disconnecting the board's 5-volt line from the HW-2036 5-volt source.

Since the replacement board was not a Heath product, we did not investigate further. Readers considering this modification should take this into account, as well as the Heath Company's service policy regarding modifications. Any problems encountered with these modifications should be brought to my attention.

E.A. Mosher, Service Supervisor
Amateur Radio & R.C. Products
Heath Company
Benton Harbor, Michigan 49022

novice roundup

Dear HR:

I just completed my third (and I hope my last) Novice Roundup, and I would like to submit a couple of comments. I know that all of the Novices and Technicians who participated thank the higher-class hams who were there with us to give out that point or needed state or section. The DX stations were also there. FB to all from my QTH.

Not so fine business to those with higher-class licenses taking a frequency and sending CQ NR, their call, and /G or /A or /E. The Generals and above have contests almost all year long; surely they get enough CQ sending practice in them. The Novice Roundup is our only contest and we need room. There are a multitude of us Novices and Techs who would be more than happy to make contact with Generals and above. But please, let the main participants have the air, and most of all, the enjoyment. Final comment: it sure would be nice if the Novices and Techs could have more than one contest a year.

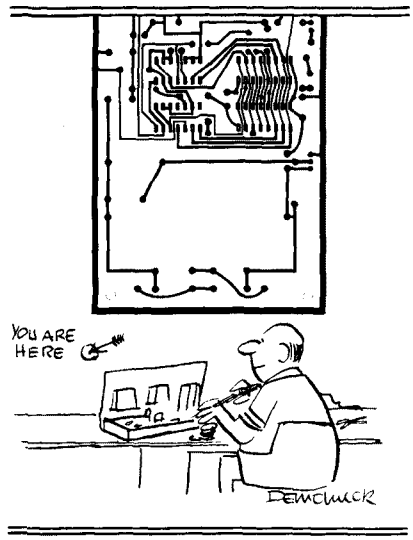
Rich Lawson, KA9AZY
Bloomington, Illinois

thanks

Dear HR:

Thank you very much for a very good radio magazine.

Carl Amberg, SMØGPC
Lidingo, Sweden



presstop

K2AHL'S RFI PROBLEMS, which he reported had resulted in a judge ordering him off the air and threatening his license, have now taken a somewhat different turn. On April 11, 1978, on the advice of his attorney, K2AHL voluntarily signed an agreement that he'd eliminate all interference to his neighbor's equipment. This in effect gave the state jurisdiction over his operating (with respect to interference), even though the ARRL's legal packet—which he'd requested and received—makes the point that an FCC license pre-empts local control of transmissions.

He Went Back On The Air after clean-up efforts only partially solved the RFI problems, so they took him back to court on several occasions for violating his 1978 agreement. At the last December hearing the attorneys proposed quiet hours, but instead K2AHL made a new agreement to shut down completely since his father (who was attending for him) indicated he'd find it "demoralizing" to observe quiet hours. Later, however, he claimed that this new agreement had been made under duress.

Under The Circumstances, the problems of the position he's put himself into cannot be resolved the way K2AHL now wishes, with or without the support of the Amateur community. It's certainly a classic example of how not to resolve an RFI complaint, and not one that should be considered to set any precedents.

A RECALL PETITION FOR CENTRAL DIVISION Director Ed Metzger, W9PRN, was circulated at Dayton by Amateurs representing the Indiana Radio Club Council. The group, principally from the Indianapolis area, is reported to be seeking the director's recall on the grounds that the League's failure to count the Central Division ballots for director in last fall's election deprived them of their votes. After former director W9NTP resigned late in that hard-fought campaign, W9PRN was declared the only eligible candidate and thus elected without ballot.

No Complaints About W9PRN's performance or competence are cited in the recall petition, which simply asks the League to "hold, as soon as is practical, a recall election to determine whether or not the current director...shall be recalled." The petition's supporters seemed principally concerned with the election process, claiming that W9NTP's resignation had been made "under duress."

A NEW BILL STRONGLY SUPPORTING Amateur Radio was introduced in the U.S. Senate on Wednesday, April 8, by Sen. Barry Goldwater, K7UGA. The bill, S 929, would provide for point-of-sale control of transmitting equipment, extend the term of an Amateur license to 10 years, and—like the old Vanik bill—give the FCC authority to set RFI standards for receiving equipment.

Volunteer Aid From Amateurs could be sought by the FCC for both exam giving and enforcement, as has been proposed in Rep. Dannemeyer's HR 2203, along with lifting of the secrecy provision of Section 605 of the Communications Act.

Sen. Goldwater Is Now Chairman of the communications subcommittee of the Senate Commerce Committee, and most of the members of the subcommittee joined him in co-sponsoring S 929.

30TH ANNIVERSARY DAYTON HAMVENTION drew over 20,000 the last weekend in April, with 185 exhibitors and a filled 1500-space flea market. Business was excellent both inside and outside throughout the long weekend. Some 1400 attended Saturday night's banquet honoring the Amateur of the Year, W9CI, and Specific Achievement Award winners WA6ITF and KH6IAF. W8WY won the complete TS-130S station door prize. Winner of the Drake "7-Line" complete station Hamvention door prize was YL N8AIM; runner-up W9CJW took home a TR-9000, and N8BLX a J.W. Miller AT-2050 automatic antenna tuner. K3KE and Ham Radio's W6NIF shared top honors in the CW competition at 40 WPM plus, while W8AU managed 18 WPM solid copy through QRM.

A 40-METER BROADCASTER operating from southern Florida, shut down twice by the FCC, went free recently after U.S. Attorney Atlee W. Wampler III requested the charges be dropped. Jose Gonzoles had freely admitted his regular anti-Castro broadcasts on 40 with a kilowatt, but despite that illegal operation and considerable FCC enforcement effort, he avoided trial. It now seems likely that other Florida illegal broadcasters, some also using the Amateur bands, will continue operating.

MENTAL INCOMPETENCE IS GROUNDS for a license denial, FCC's Chief Administrative Law Judge Lenore Ehrig has ruled in a review of K6EOA's case. K6EOA is the Los Angeles Amateur who was arrested and jailed after threating the lives of two FCC engineers who attempted to inspect his station during a jamming investigation in 1979. Federal charges were later dropped after he was judged mentally incompetent, and he later pled guilty to state charges resulting from the incident.

This Latest Decision came during a hearing on K6EOA's license. The judge also ruled that an applicant for an Amateur license does agree to abide by applicable regulations, including those that concern prohibited communications.

tune in on the world

Tips to get you started in shortwave listening



Shortwave and scanner receivers adorn the listening post of Bill Rutherford, Bardstown, Kentucky.

Most of us can remember our first exposure to shortwave radio. It might have been at the invitation of a local Amateur Radio operator. Perhaps a gift of a receiver opened our eyes to the hobby. Or did a shortwave listening (SWL) hobbyist let you hear things that fertilized your imagination?

Just a few short years ago simple shortwave receivers abounded; tube-operated sets tuned in on Radio Moscow, the BBC, and other shortwave broadcasters worldwide. But with the radio bands more congested now, simple radios are no longer capable of discriminating among the multitude of signals packed together throughout that busy portion of the electromagnetic spectrum.

the market changes

By the close of the 1960s, venerable names like Hallicrafters, National, Hammarlund, RME, Gonset, and others had disappeared from the shortwave receiver marketplace. A new hobby, CB radio, had begun to emerge as the nation's new gadgetry obsession. By the mid 1970s, good shortwave receivers at a reasonable price were unavailable. A few off-shore brands were on discount house shelves as portables, but not worthy of attention. Serious hobbyists were forced to shop around for military and commerical surplus. Tube-type receivers such as the R-388, R-390, and other salvageable radios became prime items.

And then an unexpected series of CB spinoffs shaped the destiny of consumer radios. Innovative technology, which developed competitive, low-cost CB transceivers, went to work for the shortwave hobbyist. Large-scale integration of complex circuitry into tiny chips of silicon greatly cut costs while increasing dependability and performance. Frequency synthesis and phase-locked-loop oscillator circuitry proved to have enormous potential in general coverage receivers for the shortwave spectrum. A South African firm produced the Barlow-Wadley portable, an outstanding shortwave receiver featuring the Wadley loop. Other manufacturers followed the trend.

The market is burgeoning with merchandise of outstanding quality at reasonable prices, prices far lower than equivalent performance would have cost just a few short years ago. Inexpensive beginners' radios are also plentiful for less critical listening.

what should I look for?

Along with the wide selection of modern receivers comes the bewilderment of trying to make the right decision. Which radio will suit my needs? Are there any real lemons? Does price dictate the quality? How can I be sure to pick the right radio?

Fortunately, there is considerable variety in both quality and price. Unfortunately, price does not always dictate quality! Let's take a close look at some of the characteristics that must be considered in making a choice.

selectivity

Unquestionably, the ability to discriminate among closely packed stations for single-signal reception is a prime requirement (**fig. 1**). Good receivers will have a switchable option — "selectable selectivity," if you will — to choose the degree of selectivity required for different listening challenges. Musical programs with little adjacent interference may justify wide selectivity, while Morse code and single-sideband voice reception in the crowded ham bands will require the use of sharp or narrow selectivity.

By Bob Grove, WA4PYQ, Route 1, Box 240, Brasstown, North Carolina 28902

sensitivity

There is little real difference among most modern receivers in their ability to detect weak signals, although a high noise figure can reduce apparent sensitivity. It's what the receivers do with the signals *after* they hear them that separates the wheat from the chaff! The day of the 500-foot antenna is gone; modern shortwave receivers work fine with wire antennas anywhere from 25 to 100 feet in length, so long as they are high, free of metallic obstructions, and away from electrically noisy power lines.

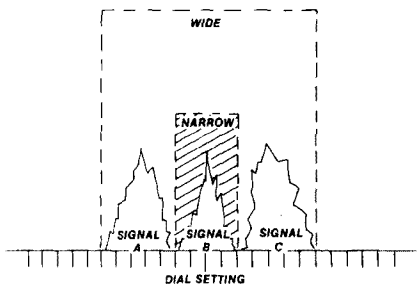


fig. 1. Selectivity is the ability of a receiver to reject adjacent signals.

stability

The ability of a receiver to remain on the frequency to which it is tuned is important when listening to amplitude-modulated signals; it is vital when listening to CW (Morse code) or SSB (single-sideband voice).

Stability comes in two varieties: thermal and mechanical. Thermal stability refers to the behavior of electronic components as they change temperature. If frequency-determining components change value as they change temperature, they have the annoying effect of shifting the received frequency.

To check a receiver for thermal drift, turn it on and tune in a shortwave broadcast station with the beat-frequency oscillator (BFO) on so that a low-pitched tone is heard. If the tone slowly changes pitch, the receiver suffers from thermal instability. A good receiver will settle down in a couple of minutes, but some receivers will drift continuously. Such receivers are virtually worthless for CW, SSB, or radioteletype (RTTY) reception.

Mechanical stability is a measure of the sturdiness of construction. As in the previous test, tune in a station with the BFO turned on. A modest rap on the side of the cabinet will betray the presence of mechanical instability by causing the note to warble or shift suddenly.

Another sign of mechanical instability is displayed as dial backlash; if there seems to be play in the dial when tuning in a station, backlash is present, making precise dial settings difficult.

frequency range

Most general-coverage receivers tune continuously from the standard broadcast band (0.54-1.6 MHz) through 30 MHz; some start even lower in frequency to include the European 1600-400 kHz broadcast band. A few begin at radio's basement: 10 kHz!

Years ago, many general-coverage receivers offered considerable frequency range, often ascending far above 30 MHz. Such receivers compromised performance for frequency coverage.

Ham-band-only receivers, which cover spaced-frequency segments (3.5-4.0, 7.0-7.3 MHz, etc.) omit the majority of the shortwave spectrum. While these receivers are of good quality, they restrict listening to Amateur communications only.

spurious response

Strong signals have an annoying habit of being heard at more than one place on the dial. Some of these phantom signals result from the inability of receivers to suppress unwanted signals of formidable strength. A good test of spurious response may be made by tuning the receiver slowly through an extremely active band of frequencies, listening for whistles to change pitch while you tune *without* the BFO turned on.

frequency readout

The close spacing of signals throughout the shortwave band demands accurate frequency readout. It is often futile to look for a station even when you know its frequency if your dial reading is inaccurate. Similarly, if you happen to stumble across an intriguing transmission which doesn't identify itself, there is no way to nail it down without knowing what frequency it's on.

Frequency displays may be analog (the continuous frequency spread is printed on a scale through which a pointer gradually moves) or digital (only the numerical characters that indicate the present setting of the receiver frequency are displayed.) Digital frequency readout is clearly the winner, taking over printed dials in all but the least expensive radios.

where to buy?

Many prominent manufacturers advertise their consumer-grade communications receivers in hobby magazines such as *ham radio*. Most Amateur Radio retail stores stock general-coverage receivers for shortwave listeners.

table 1. Typical shortwave block assignments in North America (partial list).

frequency (kHz)	class of service
3500-4000	Amateur
4000-4063	fixed
4063-4438	maritime/mobile
4438-4650	fixed, aero mobile
4650-4750	aero mobile
4750-4850	fixed
4850-5000	fixed/mobile
5000-5250	fixed
5250-5450	fixed/mobile
5450-5730	aero mobile
5730-5950	fixed
5950-6200	international broadcasting

table 2. International broadcasting frequency bands.

frequency (kHz)	meter band
2,300- 2,500	120
3,200- 3,400	90
3,900- 4,000	75
4,750- 5,060	60
5,950- 6,200	49
7,100- 7,300	41
9,500- 9,775	31
11,700-11,975	25
15,100-15,450	19
17,700-17,900	16
21,450-21,750	13
25,600-26,100	11

table 3. The most intriguing portions of the shortwave spectrum.

frequency (kHz)
4,750- 5,300
5,300- 5,950
6,500- 7,000
7,300- 8,000
8,800- 9,100
11,100-11,700
13,100-14,000
14,400-15,100
17,400-18,100

listening in — "Utes" or broadcasters?

Most shortwave devotees classify their listening thrusts into two categories: utilities (two-way communications such as military, ship-to-shore) and broadcasters (Radio Peking, Voice of the Andes). While many enthusiasts share their listening time between the services, most eventually find one of the facets of listening of greater personal interest and challenge.

the delicate art of listening

Spinning the receiver dial through its tuning range is like shooting at ducks in a fog; a good hit is pure luck! Successful listeners employ one or more tricks to guarantee results. First, it is a good idea to know what the frequency allocations are. **Table 1** gives a sample of how assignments are made in North America. Note that assignments are not based on the identities of users, but on their class of operation (fixed, mobile, maritime). A more detailed chart is published in the Federal Frequency Directory (see publications elsewhere in this article.)

Another trick of the trade is knowing *when* to listen. Shortwave signals propagate (travel) over vast distances, and just because it is 2 PM in your home town doesn't mean that daily activities are bustling in Tokyo! A world time chart can give you an edge for some types of listening.

Our sun plays a vital role in propagation of radio waves. Its intense radiation has profound effects on reflection and absorption of radio waves in our atmosphere. At night, listen to frequencies below 12 MHz, while during the daylight hours, signals above 8 MHz will be favored. Frequencies between 8 and 12 MHz are usually good around the clock.

international broadcasting

One of the major thrusts for propaganda by any nation is its radio contact with the world. Thousands of transmissions are beamed daily from virtually every point on the globe to every other point. Pro-American, anti-American, pro-Communist, anti-Communist — it's all there and makes for some fascinating listening. **Table 2** shows the target areas to tune your receiver for these broadcasts. However, not all countries subscribe to this fixed band plan. You are likely to intercept broadcasting stations throughout the shortwave spectrum; broadcasters occasionally choose to go on their own without international cooperation regarding treaty matters concerning frequencies and schedules.

table 4. Listening intrigue (all frequencies in kilohertz).

Navy	
radioteletype	14.160
Atlantic fleet	6,697; 8,972
Guantanamo Bay telephone	10,222.5
war games	9,259
Air Force	
MacGill AFB	5,683; 8,993 11,246
SAC	6,761; 9,027 11,243; 13,241
TAC	8,964
MAC	11,182
hurricane hunters	5,683; 8,993 11,232
Andrews AFB	13,247
Cape Kennedy	10,780; 20,390
NORAD	14,894
MARS	4,580; 4,885 7,324; 7,540 13,977
CAP	4,467.5 4,585; 7,635
"Spy" Numbers Stations	3,060; 3,090 5,812; 6,772 8,418
Travelers Info Service	530; 1,610
Canadian Air Force	11,233
Coast Guard	
ship-to-shore	5,680; 5,696 11,201
emergency (CW)	500
AMVER	6,506.4; 8,765 13,113
Embassies	
State Dept. CW marker (KKN50)	6,925; 23,975
worldwide pool	10,640; 13,626 14,355
South/Central America (military attaches)	7,430; 13,950
Aeronautical	
FAA regional net	7,475
VOLMET	3,001; 5,652 8,868; 13,272
ARINC	13,320; 13,328 13,356; 17,941
Russian Aeroflot	11,312; 17,936
Maritime	
simplex	4,125; 4,143.6 6,218.6; 6,221.6 8,790
calling/emergency	2,182
Great Lakes	6,516
inland waterways	6,519; 6,522
Petroleum Network	4,634.5; 4,637.5
Smugglers	7,400-7,500 14,400-14,500
Pirate Broadcasters	6,235-6,280 7,325-7,370
Clandestine Broadcasters	
Radio Free Grenada	15,045
anti-Castro	7,030-7,090

the hot spots

Intrigue permeates the shortwave bands. Smugglers, spies, undercover communications, tactical military operations and other activities never cease to pique the imaginations of hobby listeners.

Where are such transmissions to be found? Virtually anywhere. But before dismissing such catches as unpredictable, let's do a little planning. First, low-power communications cannot compete with high-power broadcasters, so that eliminates some frequency ranges. Second, time of day dictates the most likely portion of the spectrum to be in use, with the lower frequencies primarily in use at night.

Experience has shown a few key segments of the high-frequency spectrum to be favored for two-way communications by the most interesting targets of the "utilities DXers," those relentless hobbyists who pursue things that they are not supposed to hear. For a close look at those more productive hunting grounds, consult **table 3**.

try this sampling

Most of us enjoy the cookbook approach to listening: look up a listing in a frequency directory and dial it up. Some of the more interesting stations can be tuned in by this straightforward approach. Let's take a look at a few listings (**table 4**). Most transmissions are SSB. Perhaps something here may capture your interest!

listeners' clubs

A number of clubs exist for the pleasure of serious shortwave hobbyists. For information about these clubs, enclose a self-addressed envelope along with your request to: ANARC (Association of North American Radio Clubs), 409 Laconia Lane, Schaumburg, Illinois 60193.

publications

Several outstanding publications are available to assist the SWL enthusiast. Among them are: *Federal Frequency Directory, Communications Monitoring, Radio Communications Guide, World Radio TV Handbook, Confidential Frequency List*, and the *Sounds of Shortwave* cassette.*

a final word

Listening in is an American privilege. Perhaps nowhere else in the world are laws regarding the interception of private correspondence so lenient. But there are regulations, and listeners should be apprised of their obligations.

*Available from Ham Radio's Bookstore, Greenville, New Hampshire 03048 or Grove Enterprises, Incorporated, Brasstown, North Carolina 28902. An interesting catalog may be obtained from Grove Enterprises, Incorporated.



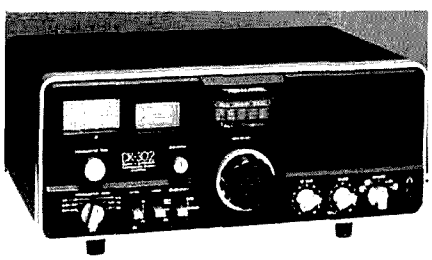
Yaesu FRG-7



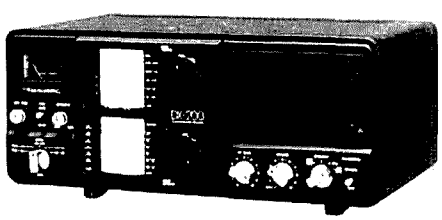
Kenwood R-1000



Drake R7



Radio Shack DX-302



Radio Shack DX-200

At left, a few of the receivers suitable for shortwave listening that are currently on the market. Shortwave listening is often the first step to an Amateur license, and many active Amateurs are also confirmed SWL enthusiasts.

Section 605 of the *1934 Communications Act* specifically prohibits the divulgence to another person the nature of a communication which you heard that was not directed toward you. Nor are you allowed to make use of that information for your own gain. The act is enforced by the FBI. Hobby radio listening is educational recreation; but only the information transmitted by broadcasting stations is intended to be repeated.

The hobby of shortwave listening is at a level greater than ever before in history, and its ranks are growing. Tune in on the action. There's a world of listening out there!

reference

1. Bob Grove, WA4PYQ, "Shortwave Listening, a World of Intrigue," *Ham Radio HORIZONS*, November, 1980, page 13.

ham radio



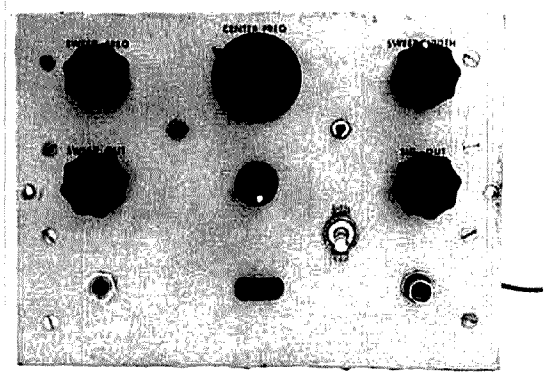
A useful instrument
for testing
multipole filters

stable wideband sweep generator

Several articles have appeared recently in the Amateur literature describing crystal ladder filters. I've been interested in selective filters for many years, and after reading an article by G3JIR,[1] I decided to try building a ladder filter.

It soon became apparent that it would be difficult to adjust a multipole filter (I had chosen an eight-pole filter) without a sweep generator and oscilloscope to produce a pattern of the filter's passband.

I didn't have a sweep generator, so I decided to build one. After trying the RC oscillator circuit suggested by K6DYX,[2] I was convinced that a more stable oscillator was needed when working with a highly selective filter in the 9-10 MHz range. The circuit I chose uses frequency conversion, thereby making it possible to set up any frequency from 10 kHz to about 150 MHz. By subtracting the two oscillator frequencies (sweep oscillator and crystal oscillator), it's possible to produce a frequency-modulated signal as low as 10 kHz. By adding the two frequencies, usable signals can be produced well into the VHF ranges.



Front panel of author's homebrew sweep generator.

typical test setup

The sawtooth generator (**fig. 1**) provides a linear sweep signal to the sweep oscillator as well as a ramp for the oscilloscope. The frequency-modulated signal from the sweep oscillator is mixed with the crystal-oscillator signal in the balanced modulator to provide an amplified signal to the filter under test. (The filter

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should be terminated with the proper impedances while the alignment is being made.)

I used modular construction on homemade PC boards. Most of the construction is not very critical, but special attention should be paid to keep the sweep oscillator as stable as possible and to keep leads *short* if VHF operation is intended.

the circuit

Fig. 2 is a schematic diagram of the wideband sweep generator. The circuits are mounted on individual PC boards (indicated by dashed lines). Operation of the essential circuits is as follows.

Sawtooth generator. R3 controls bias to Q1, which, in conjunction with C2, sets the sweep frequency at about 30 Hz. Q1 drives Q2, which in turn drives the noninverting input of the 741 op amp. The dc voltage at the output of the 741 is balanced by R2.

Sweep oscillator. The sweep oscillator is a grounded-drain Hartley circuit. It drives Q4, a source follower, which is direct-coupled to Q5. The output from Q5 is fed to one input port of the double-balanced mixer. The slug in L1 tunes the oscillator over about a 1-MHz range (4.5-5.5 MHz), and C1 provides fine tuning of about 10 kHz to provide easy adjustment of the center frequency. The signal from the sawtooth generator is applied to tuning diode CR1 to frequency modulate the sweep oscillator.

Crystal oscillator. This is a Pierce oscillator, which allows a wide selection of oscillator frequencies for various output-frequency requirements. It is buffered by Q7 and Q8, and the output is fed to the balanced mixer to be mixed with the output of the sweep generator.

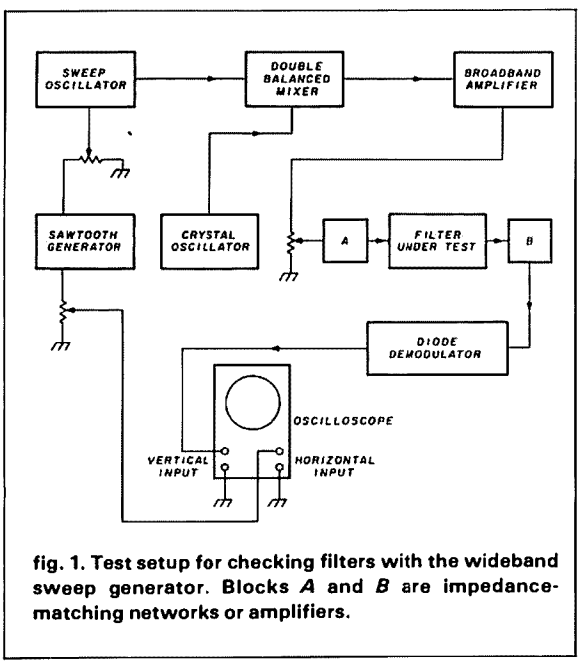
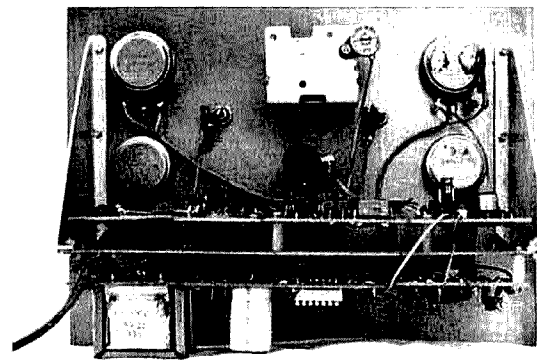
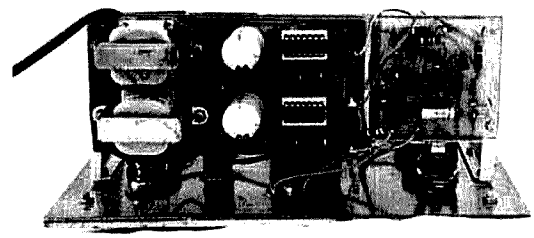


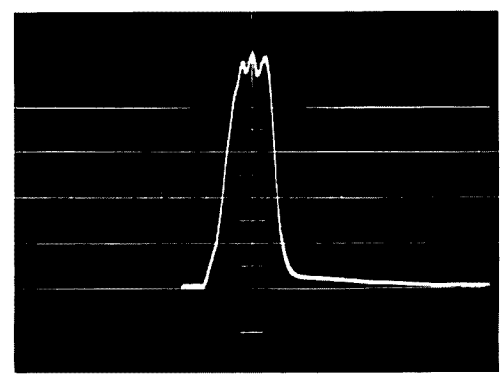
fig. 1. Test setup for checking filters with the wideband sweep generator. Blocks *A* and *B* are impedance-matching networks or amplifiers.



Rear view of panel showing construction of the sweep generator. Upper left is the sweep-width control; center, center-frequency control; right, sweep-frequency control. At lower left is the signal-output control; center, dc-balance control, and lower right is the sweep-output control. Power supply and crystal oscillator are mounted on the bottom circuit board.

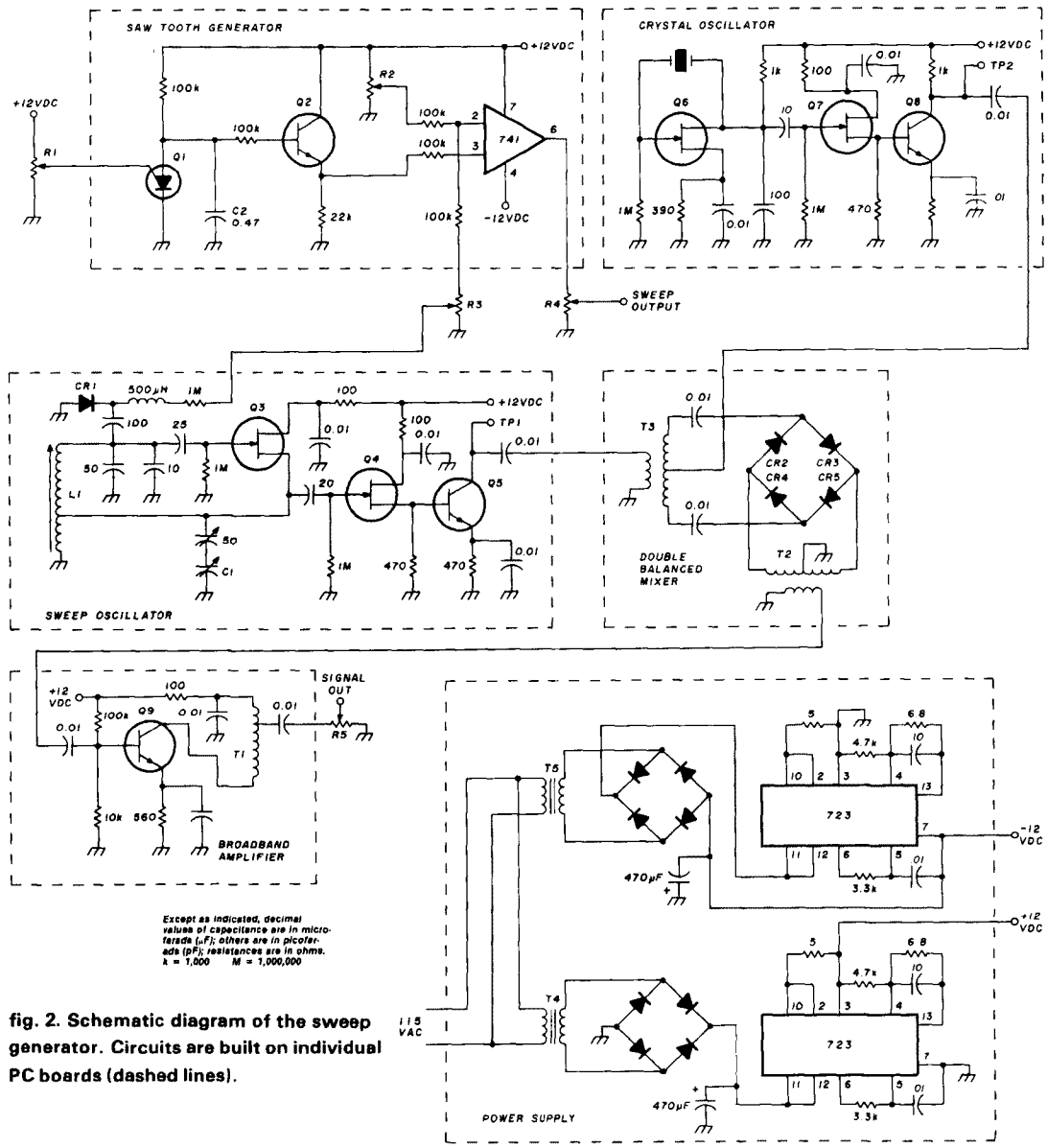


Under-chassis view showing the power supply (left) and crystal oscillator.



Oscillogram showing the passband of an eight-pole filter.

C1	25-pF variable mounted on panel (center frequency control)
C2	0.47-pF low-leakage capacitor
CR1	tuning diode (MV2203)
CR2-CR5	1N914 or equivalent
L1	36 turns No. 26 (0.4 mm) tapped at 12 turns, 1/2" (25.4 mm) diameter slug-tuned form mounted on panel
Q1	unijunction transistor, Radio Shack #276-2029
Q2	2N2222
Q3	MPF 102
Q4	MPF 102
Q5	2N2222
Q6	MPF 102
Q7	MPF 102
Q8	2N2222
Q9	2N2222
R1	25k pot mounted on panel (sweep frequency)
R2	25k trimpot (dc balance on sweep output)
R3	25k pot mounted on panel (sweep width)
R4	25k pot mounted on panel (sweep output)
R5	10k pot mounted on panel (signal out)
T1	12 turns No. 30 (0.25 mm) Trifilar wound on Amidon T50-72 core (4:1 ratio)
T2,T3	12 turns No. 30 (0.25 mm) Trifilar wound on Amidon T50-72 core
T4,T5	12V 300 mA Radio Shack #273-1385



Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms. k = 1,000 M = 1,000,000

fig. 2. Schematic diagram of the sweep generator. Circuits are built on individual PC boards (dashed lines).

Broadband amplifier . The output of the balanced mixer is amplified by Q9 to a level of about 2 volts. This voltage is more than adequate for checking filters or aligning receivers and will usually be enough to allow using an oscilloscope of lower sensitivity.

A diode demodulator (**fig. 3**) converts the rf signal from the filter to dc, thereby eliminating the need for a high-frequency oscilloscope.

During adjustment of a filter, I recommend that the sweep width be reduced as far as possible while still allowing you to see the ripple on the nose of the pattern. This makes it much easier to note changes as adjustments are made.

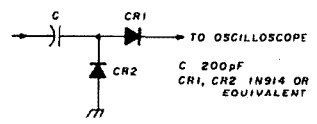


fig. 3. Schematic diagram of a diode demodulator, which converts the rf signal from the filter under test to dc.

measurements

Measuring the bandwidth and the nose ripple of a filter can be made by plotting the passband response. To do this, connect the output of the diode demodulator to a low-scale VTVM and reduce the sweep width to zero. Connect a frequency counter to the output of the signal generator. Slowly tune the generator through the passband of the filter and note the meter reading and the frequency as indicated on the counter. By plotting meter readings versus frequency a pattern of the filter passband will be produced. Following are the characteristics of a filter I recently constructed from surplus CB crystals:

center frequency	9.565 MHz
6-dB bandwidth	2.3 kHz
60-dB bandwidth	3.9 kHz
80-dB bandwidth	4.7 kHz
nose ripple	1.5 dB
insertion loss	10 dB

acknowledgments

I'd like to acknowledge suggestions from W7NO and W7BZ during the development of this project.

references

1. J.A. Hardcastle, G3JIR, "Some Experiments With High-Frequency Ladder Crystal Filters," *QST*, December, 1978, page 22.
2. W.C. Smith, K6DYX, "An Inexpensive Sweep Generator," *QST*, October, 1976, page 17.

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May be used for
- Guy wire strain insulators
- End or center insulators for antennas
- Construction of antenna loading coils or multiband traps

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Patent No. 4,091,350

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D-40	40/15	66'	25.95	21.95
D-20	20	33'	24.95	20.95
D-15	15	22'	23.95	19.95
D-10	10	16'	22.95	18.95
Shortened dipoles				
SD-80	80/75	90'	31.95	27.95
SD-40	40	45'	28.95	24.95
Parallel dipoles				
PD-8010	80,40,20,10/15	130'	39.95	35.95
PD-4010	40,20,10/15	66'	33.95	29.95
PD-8040	80,40/15	130'	35.95	31.95
PD-4020	40,20/15	66'	29.95	25.95
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S-80	80/75		$11.95/pr.	
S-40	40		$10.95/pr.	

All antennas are complete with HI-Q Balun or HI-Q Antenna Center Insulator, No. 14 antenna wire, ceramic insulators, 100' nylon antenna support rope (SD models only 50'), rated for full legal power. Antennas may be used as an inverted V, and may also be used by MARS or SWLs.

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Dealer Inquiries Invited

DXer's diary



By Bob Locher
W9KNI

It's been a beautiful June day, one of those rare jewels that only late May and early June can deliver to the Midwest. Seventy degrees, dry with low humidity, a gentle breeze, altogether a perfect day.

Thoughts of any kind of useful work were cast aside early, like those of the Mole about doing his spring cleaning in *The Wind in the Willows*. A Saturday like this just can't be wasted, and I didn't.

A long bicycle ride in the country, hamburgers charcoaled on the grill; a perfect day. Now it's time for a look around the bands. The high-pressure cell sprawled across the Midwest certainly will keep thunderstorms away; the bands should be relatively quiet and free of QRN.

I ease into the operating chair with a bit of a wince; perhaps I did overdo it for the first long ride of the season. But I'm glad I did, even if I'll pay with sore muscles tomorrow. I flip the master safety switch on, and settle the headphones over my head as the receiver comes to life.

Let's see here, it's 0130 Zulu, 8:30 PM Central Daylight Time. Fifteen ought to be in pretty decent shape. I flip the bandswitch, and start tuning the dial. Yes, there are lots of signals. That's fine; the band is obviously pretty wide open.

What direction shall I point my antenna? The band could still be open to Europe, but so what if it is? I have everything in Europe except Albania and Mount Athos, and I'm sure not likely to hear one of them. Besides, they'll all be in bed.

If conditions are good, the band is probably open over the polar regions, with deep Asian Soviet, Indian, and Sri Lanka stations possible. It's morning in those parts. But those stations tend to stay on 20 meters, rather than on 15, and I want to try 15 for a while tonight. Still, it's a thought; some of them may well be on the band.

I could point east into Africa. At this time of year, central and southern Africa ought to be a lead-pipe cinch for propagation on 15 at this time of day. But equally, it's too early, and they are most likely all in bed, even though conditions are fine. Still, the path into the Indian Ocean may be open, and it's morning there.

I could point the antenna south-south east, good for Central and South America and Antarctic continent. I don't need anything on the South American continent, but sure could use both the South Orkney Islands and the South Sandwich Islands. The path should be wide

open, and it's not too late for them to be up. It's definitely a possibility.

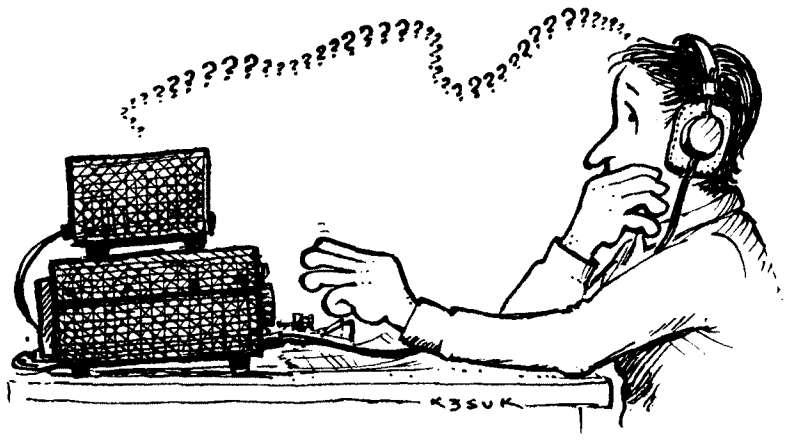
I could go southwest, across the fabled isles of the South Pacific, and on into Australia and New Zealand. Visions of swaying palm trees and pounding surf on coral reefs cross my mind; but heck, it can't be any nicer anywhere than it was here today. It's mostly afternoon across that path, Saturday afternoon east of the date line, Sunday west of the line. Either way, a weekend with good chances of activity from stations in that area. I wonder if VK9NV works 15?

There's always the northwest bearing, to Japan, Guam, the North Pacific and Southeast Asia. I could certainly use a couple of those places, but there are two chances of snagging one of them — slim and none. Like Cambodia, Burma, or Laos.

Anyhow, I decide on my plan of action. I'll start looking north, across the transpolar paths. I'll have a good look around, then turn the antenna east-northeast to bisect the great-circle path between Europe and most of Africa. Then, after another good snoop around, I'll rotate the antenna into the southeast, and have a look for those Antarctic islands.

If I fail to find anything of interest there, we'll try that shot across the wide Pacific, aiming west-southwest. And if that path is really good, we might get a long path peak into the Middle East and Northwest Africa. When I've milked that path dry, we'll haul round to the northwest, and have a look at the Orient and Southeast Asia. Then, I'll back the antenna round to north, and start all over again.

I move the receiver dial to 21,000 kHz and begin tuning up the band, with the antenna due north. The band is definitely quieter with the antenna north, but that certainly doesn't mean it's dead. I hear a lot of signals, most of them pretty weak. I listen to call signs; they're from all over. There's a GM, Aberdeen, Scotland. And there's an OH, a Finn. OK, not all Europeans are in bed. And of



course, it's the weekend for them, too. I keep tuning.

There's a signal with just a touch of chirp; nice fist, "CQ CQ DE AP2BQ AP2BQ AR." I pick up my 2-meter mike, and call it in on our DX channel, "AP2BQ, that's Alpha Poppa Two Bravo Quebec, twenty one oh one nine, twenty one oh one nine, from W9KNI." I wait a moment. No one asks for a repeat, so I begin tuning again. Pakistan is always an interesting catch, but I have it, so I keep on tuning.

Hmmm. The band is full of signals. There's a JA — pretty decent signal, too, considering that the antenna isn't on him. There's a raspy signal calling CQ. OK, it's UL7BDG. Gosh, the band seems to be as nice as the weather is.

I continue tuning higher up the band, getting a feel for it, tasting its flavor. Even with my antenna north, I hear a lot of stations from other parts of the world that come in on other bearings. What's that — a loud station with lots of backscatter, obviously a W or a VE, calling VP8AI. I grab my note card on VP8s — there's VP8AI listed. Faulkland Islands. OK, I don't need that one.

I keep a note card on the Antarctic stations because their prefixes are not clear indicators of their DXCC country status. For example, a VP8 could be Antarctica, the Faulkland Islands, the South Shetlands, South Georgia, the South Orkneys, or the South Sandwich Islands. Since I need several of these, I always listen to VP8 call signs, and I keep a list made up of who is known to be where. Knowing that VP8AI is in the Faulklands saves wear and tear on the finals, not to mention the operator.

The other Antarctic area prefixes are easier that the VP8s. The Argentines have their own system. If the first letter after the number is a *Z*, the station is Antarctic. The second letter, the letter after the *Z*, will tell you which island. Hence, LU1ZA is South Orkneys; the *Z* for Antarctica, the *A* for South Orkneys. LU3ZY is the rare South-Sandwich station, while LU4ZS is South Shetland. LU3ZC is Antarctica.

The Antarctic Russian stations all have 4K1 prefixes and all are on the relatively common Antarctic continent, except for one station, 4K1F, who is in the South Shetlands.

The Chileans use CE9 for Antarctic stations, with CE9AA to CE9AM call signs used by stations on the Antarctic continent, and stations on the South Shetlands using CE9AN through CE9AZ calls — not that there are that many calls issued and in use.

I must keep all this in mind, knowing that we have propagation into that part of the world. VP8AI won't do me any good, but maybe on the next kHz...

But my antenna is still north, and I'm wool gathering entirely too much. It's deep Asia we're looking for on

this pass. I keep tuning the receiver.

There's a signal with the marks of a long propagation path to it. He's calling CQ. Let's see who it is. OK, it's UH8HGB. I've worked four or five, but I still don't have a QSL, so I'd better give him a call. He's strong enough; maybe I can do this one barefoot, without turning on the linear. He signs, and I call, "UH8HGB UH8HGB DE W9KNI W9KNI W9KNI AR." I use the longish call, *because* from the sound of his fist he may well be a rather new operator. Ah, he comes right back...

He keeps the contact brief, and that's fine with me. He definitely appears to be a new operator; that's to my advantage, as he's more likely to QSL. We sign clear, and I start my tuning-up-the-band bit again.

There's a signal: "1RT AR," with the marks of another Asian signal impressed from the transpolar path. Hey! Could it be? *Naw, not a chance.* Still, it could be. *Naw, he's never been reported on 15.* Hey, what the heck! No one's calling him, give a call. *Naw, it's a waste of time.* Oh go ahead, you have nothing to lose. *What the heck, see if I care.*

Having settled my internal debate, I bring the VFO up, and try to zero the frequency where I heard the tail end of that station.

"1RT? 1RT? DE W9KNI W9KNI AR K."

"W9KNI W9KNI DE A51RT A51RT GM OM ES TNX CALL..."

I'm in shock. My heart instantly switches into high gear. My hand trembles. I feel like my first oil well came in as an exploding gusher. It's *BHUTAN!* Exotic fastness of the High Himalaya, the land of the Dragon, the land of the Druk, rarest of the rare..."NAME HR RANDHU RANDHU HW COPY? W9KNI DE A51RT KN."

My fingers feel like a funny combination of lead and rubber, but my trusty Bencher paddle picks up, "R A51RT DE W9KNI R TNX RANDHU FOR QSO ES VY PSED QSO RST569 569 QTH *HR CHICAGO CHICAGO* ES NAME BOB BOB PSE UR QSL FOR NEW COUNTRY HW CPY A51RT DE W9KNI AR KN."

"R W9KNI DE A51RT FB BOB ES TNX RPT FM CHICAGO..."

I pick up my 2-meter microphone, "Hey, I got a good one. It's A51RT, Bhutan, that's A51RT, twenty one oh sixty seven, Alpha Five One Radio Tango, twenty one oh sixty seven, I'm in QSO, from W9KNI."

"...QSL SURE 73 ES GOOD DX FROM THIMPU BOB W9KNI DE A51RT SK."

"R FB RANDHU BEST 73 ES TNX QSL SURE A51RT DE W9KNI SK EE."

I sit there in shock. I can breathe now. There are about a dozen stations calling him. From the sound of it they are mostly locals alerted by my 2-meter call. Got to get the log straight.

I look at my calendar watch; OK it's the 6th. But GMT date would be the 7th, because it's past midnight in Zulu time. I already had the time in the log — 0206 Zulu. I write in the date: A51RT, 21 MHz, 569 X 579, 150 watts.

Hah! That's right, I worked him barefoot. Had I known that he was going to be there, I certainly would have had the linear on and running. I never run the linear until I need it. New finals cost too much to be idly wasting filament time. Besides, my 3-500Z can be fully operational from a *cold* start in under *10* seconds *flat*. But I never needed it for this one.

Bhutan! The number of hours I've spent looking for him on 20 meters. Then I nearly break my leg tripping over him on 15. Ah well, as they say, it's not how you get them but how many you get. But you've got to know that I'm going to brag about working Bhutan barefoot.

I listen to the frequency again. Yep, he's still in there...

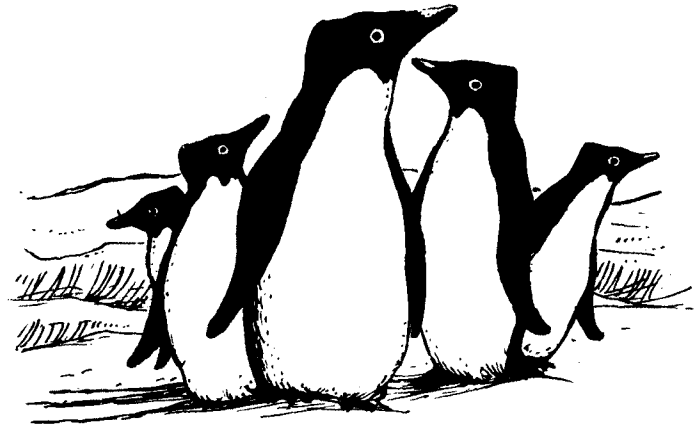
"TNX JIM FOR QSO ES QSL SURE BK 73 ES DX FM THIMPU MUST QRT NW QRL W9WU DE A51RT SK CL EE."

The 2-meter radio pipes up: "Hey, W9KNI, here's W9WU. Thanks, Bob. For that one I owe you a case of Augsburg, my man!"

You know you've snagged a rare one indeed when WU offers such bestowments.

I listen on to the chatter on 2 meters a couple more minutes. WU certainly is catching a lot of good-natured static about his luck, lack of operating skills, and so forth, from the fellows that came up short when the A51 pulled the switch. WU is thoroughly enjoying it, and, of course, so am I.

But with the band open like this, I ought to keep tuning. I resettle the earphones and begin turning the knob again. I find a couple Siberians, and one UL7, but it becomes obvious that I've milked the path for all it's worth. And its worth was high. The A51 is, and probably always will be, one of the rarest. And I got him bare-



foot! That's one I'll always remember, I know.

I consider my plan of attack. It's 0220 Z, 9:20 PM Central Daylight Time. And it's 3:20 AM in Western Europe. They're all in bed. I was going to try the African path next, but it's really too early for those fellows to be up; and hearing people calling VP8AI has turned my attention to the far, frozen Antarctic.

I pull the antenna around to 160 degrees, the bearing that my *Second Op* tells me is for the South Orkneys. That's close enough for any of the Antarctic islands. I run the receiver back down to 21,000 kHz and start my hunt back up the band.

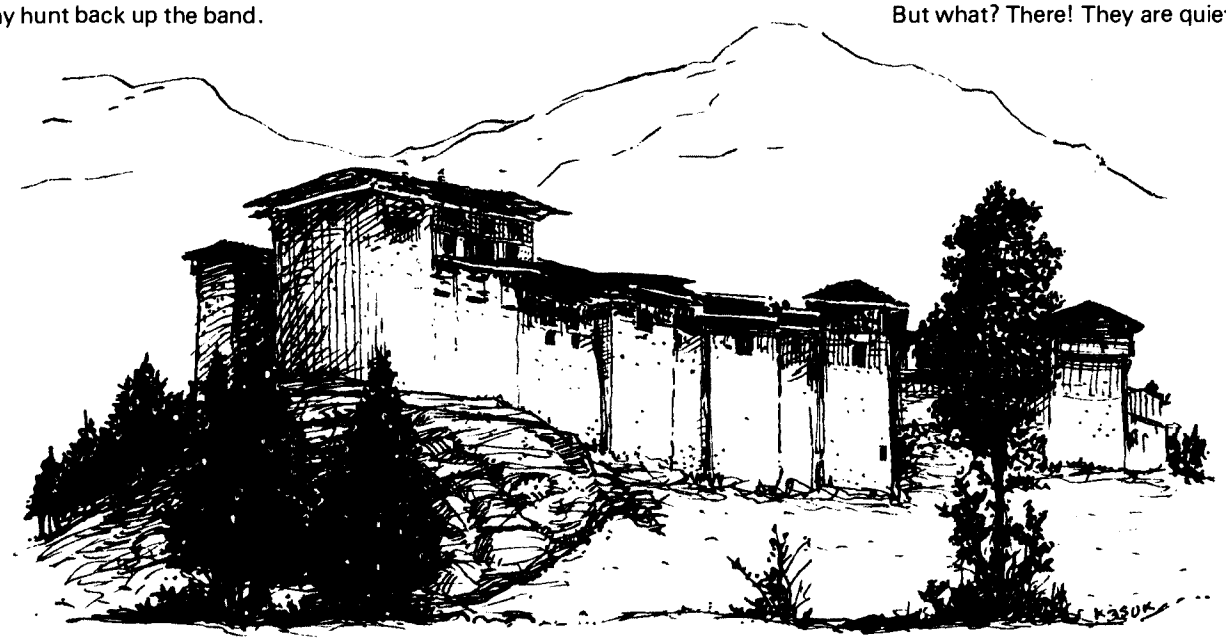
intently signing their calls. Wonder who they're onto? I bring my VFO up quickly. Never hurts to be ready. There. They've all stopped calling now; and yes there's someone coming back.

"589 589 HR BK NAME IS ROGER ROGER ES QTH PORT STANLEY PORT..." OK, it's a VP8 in the Faulkland Islands. Wait, he's signing his call; let's see who he is. OK, it's VP8TN. H'mm. Check my laundry list of VP8s. He's not on it, so let's get him added. There, VP8TN — Faulkland. I won't need to waste time on him in the future trying to crack a pile-up for one I don't need.

Where? The side nulls cross, roughly, the path to Europe on the one side, and the path to New Zealand on the other. If the station that the pile-up is after is on frequency and I'm not hearing him, it's a pretty safe bet that he's buried in the side null of my antenna. Otherwise, I should hear something, even if very weakly.

Hey, they're calling again, and there are more of them. There's W3KT. And N4WW. And K5LM. This ain't no Sunday School picnic — the heavies are out in force. As I recognize their calls, and the sense of urgency they display, I myself get hyped.

But what? There! They are quieting



I immediately rediscover the problem with tuning this path — very loud South-American stations. First it's LU8DZ, doing a drumbeat on my ears. Then it's PY7RO. But it's natural; the band is obviously wide open, and I'm looking down the jaws of their arrays as they look down mine. No wonder they are 30 and 40 dB over S-9.

There's a CP5; not very common, especially on CW, but I have it, in the log and on the wall. I call it in on 2 meters, and keep tuning.

Suddenly, I find myself in a mini pile-up; perhaps a dozen stations

Listen to that crowd call! They sure do seem intent tonight. That's not very nice — he hasn't finished his last QSO. Yeah, there he is. Wait; he's calling QRZ, and yet people all around him keep signing their calls. He's not that weak.

Hey, wait a minute. They're not calling him at all. They are all calling someone else, and from the sounds of it rather frantically. Who?

I wait. The pile-up dies down, and I tune carefully through it looking for their prey. Not a whisper do I hear. Nothing... I run the gain up. Nil. Oh oh. Should I turn my antenna?

down again. Whomever they are chasing must be back to someone. I hit the antenna rotor, and swing the antenna around to the southwest. Maybe there's something on in the Pacific.

Once again, I strain my ears as the antenna rotor responds to my command. I'm almost crawling into my headphones trying to wring out information. Then I hear, "R LU3ZY DE W3KT R TNX ISIDRO UR 589 589 QTH PA PA NAME HR JESSE JESSE HW COPY? LU3ZY DE W3KT KN." As 3KT signs, a bunch of fellows drop tail end calls.

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It's the South Sandwich isles — the rarest of the Antarctic group. Until LU3ZY started up recently, the Islands had been off the air for over ten years. There had been recent reports of activity, but only on Spanish phone, and outside the U.S. phone bands. But now, they apparently are on CW. Hot Dog!

But where is he? I turn the antenna hurriedly back to 160 degrees. That, at least, is one dilemma I'm done with now. He must be working split frequency. Let's start looking lower for him.

I find him almost immediately, as he comes back to someone. Nice signal, too. A clean, honest 579, with a trace of a chirp, probably due to a weak main supply.

No wonder I was confused. The LU3 is listening up five, putting his pile-up squarely on top of the VP8. What a mess. But the LU3 is pretty well in the clear, so we have a good shot at him.

This time I quickly turn the final on. A quick touch up on the tuning after presetting the knobs, and I'm ready. OK, let's see who he's working now. I want to be ready.

"OK JIM ES TNX QSO MUST QRT FOR WATCH DUTY 73 W9VNE DE LU3ZY SK CL."

Aggggghhh!

Oh well, I look at the clock, and make note to transfer to my blackboard. OK, it's 0258 Zulu. His watch duty must start at 0300 Zulu. I note the frequency, 21,063. If he's keeping watches, there's a very good chance that he'll be on again tomorrow. And I'll be there. And so will a bunch of others. But that's OK. When I took up DXing nobody promised me a rose garden.

Well, you win a few, you lose a few. But you sure aren't going to get a complaint from me. Bhutan! Wow! I'm still riding high.

I've done enough for one day, a really super day. I turn the rig off, ground the antenna, and head up the stairs. I can just catch the ten o'clock news. Bhutan! Wow!

ham radio

simple, high-frequency mobile antenna matcher

Are you frustrated because you can't move up and down the 40- and 75-meter bands while driving down the freeway? The stumbling block, of course, is the narrow bandwidth of the antenna system on these bands, particularly on 75 meters. The higher the antenna Q, the worse the situation.

Fortunately, the simplest remotely operated antenna matcher/tuner for high-frequency mobile operation also just happens to be highly efficient, very effective, and ridiculously easy to operate. It consists of just *one lonely variable capacitor in the car trunk*, tunable from the driver's seat. In my case, this is accomplished using a *limber* 1/4-inch (6.5 mm) plastic rod.

In a typical two-door sedan it's easy to rotate the capacitor *manually from the driver's seat*. With this simple arrangement one can move from 7150 to 7300 kHz with a VSWR not exceeding approximately 1.1. On 75 meters, the VSWR is less than 1.2 over most of the 3800-4000 kHz band; it increases rapidly to about 1.5 at the phone-band edges. The exact numbers will vary slightly with antenna mounting, arrangement, car size, and road surface.

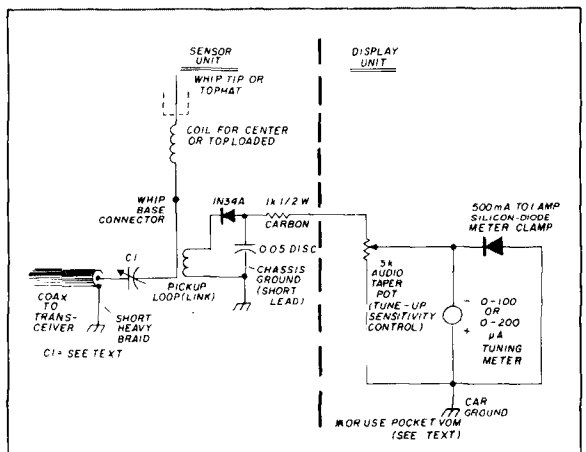


fig. 1. The "Simplest Remote Mobile Antenna Matcher" consists of a sensor and display unit. Mechanical parts consist of a tuning capacitor and a drive shaft, appropriately supported between driver's compartment and antenna.

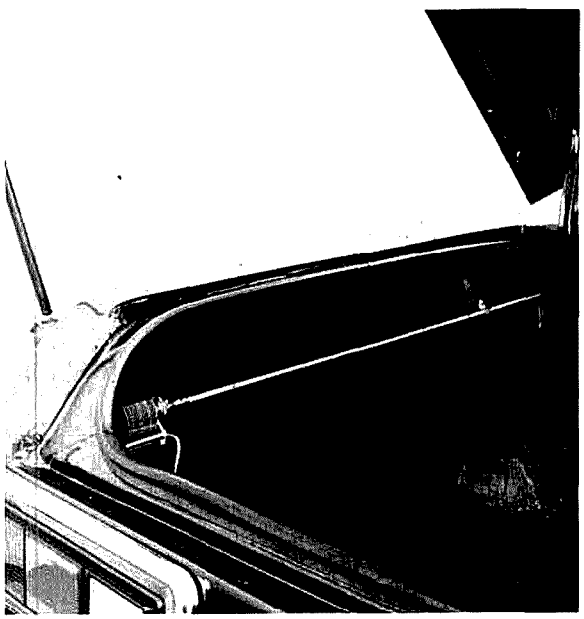
By Woodrow Smith, W6BCX, 2117 Elden Avenue, Apt. 20, Costa Mesa, California 92627

typical application

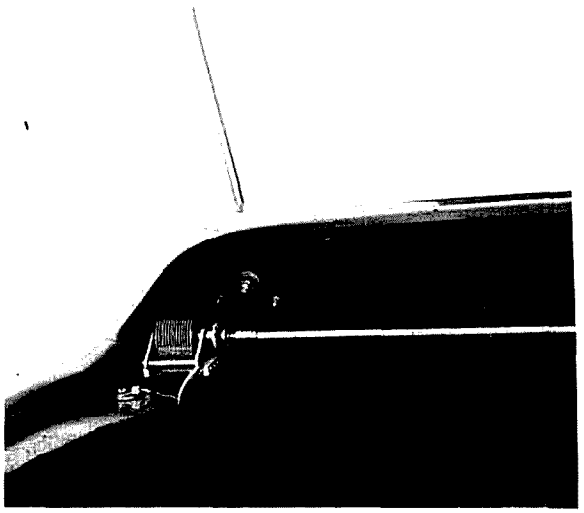
In my two-door sedan, the limber shaft drives a planetary gear arrangement attached to the capacitor frame. Unfortunately, this method doesn't lend itself too well to a four-door sedan configuration, although it can be done if you're willing to go to the trouble of running the shaft through the passenger compartment at floor level — not an easy trick but still feasible on many four-doors. In this case, the driver reaches down instead of left and over to change frequency.

My Mercury Monarch is probably typical of most compact and intermediate two-door sedans of domestic manufacture circa 1970-80. The limber shaft terminates at a small knob located at the forward edge of the left-quarter plastic trim panel (to the rear of the door frame), slightly above the armrest. The shaft runs snugly against the trim panel and is rarely noticed by passengers. Its height is such that it's possible to reach it briefly without interfering with normal driving tasks. The best height seemed to be about flush with the back of the seat (not the headrest).

Once the antenna for a particular band has been trimmed for equal VSWR at the band edges, it's not necessary to touch the antenna again. Just rotate the capacitor for maximum *radiated* power. (I assume the rig is an all-solid-state transceiver with untuned 50-ohm output).



Tuning capacitor and limber shaft mounted in author's car. Planetary drive at capacitor prevents backlash and wind-up "hop" by reducing torque at capacitor.



Another view of the tuning capacitor and coupling assembly installed in the author's car trunk.

circuit

One arrangement I've used successfully is shown in **fig. 1**. A small, imported, illuminated tuning meter of questionable ancestry is mounted on the back side of the sun visor (to be at eye level and close enough for easy reading while driving). Voltage to actuate the meter is derived from a 1N34A diode inductively (link) coupled to the lead between the capacitor and the antenna base connection. (Before I found the tuning meter I used a pocket multimeter placed on the seat. It had the advantage of sensitivity selection for tune up, but had the disadvantage of not being at eye level.)

The word *limber* is appropriate in describing the drive shaft because, unlike a flexible shaft with an outer sheath, the limber shaft is simply a 1/4-inch (6.5-mm) shaft stiff enough to avoid objectionable wind-up yet flexible enough to allow for some misalignment, or change in direction.

The limber shaft is made to behave by supporting it in guides spaced at appropriate points (photo). Loose-fitting cable clamps act as shaft guides. The use of the planetary drive unit eliminates backlash and wind-up hop by reducing the torque that the shaft must deliver. At the same time, it acts as a friction brake to discourage the inherently unbalanced capacitor rotor from being vulnerable to shock and vibration.

The planetary drive I used has a ratio of 6.5 to 1,

table 1. Readings and observations, 40 meters.

initial conditions

"High power" 40-meter Hustler resonator (coil and tip) RM-40-S. (Standard resonator RM-40 gave readings nearly identical.)

obervations

best VSWR with no shunt or series C		1.15
best VSWR with optimized shunt C (≈260 pF) and tip lengthened accordingly		1.0
best VSWR with optimized series C (≈75 pF) and tip lengthened accordingly		1.0
1.5-VSWR bandwidth; no tuning or adjustments. (1) no C, (2) optimum shunt C, and (3) optimum series C		
all three configurations		≈58 kHz
While shunt or series C was required to bring the VSWR below 1.15, the 1.5-VSWR bandwidth with *fixed tuning* is not changed significantly.		
While optimum shunt C can reduce VSWR to approximately 1.0, there's no reactance compensating effect if shunt is optimized as frequency is increased or decreased. Therefore, to make the tunable capacitor effective over as wide a frequency range as possible, it must be in *series*.		
VSWR obtained with resonator tip optimized for 40-meter phone and tuning only with series capacitor	7150 kHz	1.1
	7300 kHz	1.1
VSWR with resonator tip optimized for entire 40-meter band	7000 kHz	1.22
	7300 kHz	1.24

which appears to be about optimum — but anything between 5 to 1 and 10 to 1 should be satisfactory.

A few *electronic* parts stores carry planetary drives (such as the British-made Jackson Bros.). But if you have trouble locating one, note that they are available as replacement parts for a number of ham transceivers.

My original plan was to rig up a motor-driven mechanism using the actuator from a remotely operated telescoping auto-radio antenna obtained from an auto parts junk yard. However, obtaining and assembling the stuff turned out to be a more formidable task than expected. So I made a lashup using manual drive *through the* limber shaft. It has been so satisfactory that, nearly three years later, the motor-driven project still is awaiting development.

typical installation

I use two separate and considerably different high-frequency mobile-antenna installations above the same ball mount. The first is a standard Hustler installation and is normally used around town because with it it's easy getting in and out of the garage and driving up to canopied gas pumps (and along residential streets with low telephone lines) without having to worry about the antenna hitting something. The other antenna is much more elaborate and is used only on out-of-town trips.

results

Because the matcher/tuner works equally well with both systems, and because so many Hustler installations are already in use, the VSWR figures (**tables 1** and **2**) are actual readings taken with the standard Hustler installation, and with the car in a vacant parking lot on asphalt paving. Tuner performance isn't significantly different on other paved surfaces or with other top or center-loaded antennas.

To minimize interference and avoid spurious VSWR readings as a result of harmonic output, all readings were made with the smallest amount of drive to my 350-XL final amplifier that would produce usable readings with the VSWR meter set for maximum sensitivity. After all VSWR measurements were completed, the meter made an unofficial visit to a calibration lab, where it was checked for accuracy. Readings below 2.0 on the meter turned out to be sufficiently accurate on the bands of interest that application of a correction factor was not necessary.

table 2. Readings and observations, 75 meters.

initial conditions

Standard 75 meter Hustler resonator RM-75

observations

best VSWR with no shunt or series C, tip length optimized for F		1.4
best VSWR with optimum shunt C (≈600 pF) at center of phone band and tip *lengthened* accordingly		1.0
best VSWR with optimum series C (≈240 pF) at center of phone band and tip *lengthened* accordingly		1.0
1.5-VSWR bandwidth; no tuning or adjustments.		
no shunt or series C (VSWR 1.4 at resonance)	spot frequency only	
with optimum shunt or series C at center frequency	≈19 kHz	
To stay below 1.5 VSWR, only spot (fixed) frequency operation is possible without shunt or series C.		
Even with optimum shunt or series C at center frequency, it isn't possible to move F very far when tip length and C are fixed.		
VSWR obtained with resonator tip optimized for 75-meter phone band and tuning only with series capacitor	3800 kHz	1.5
	4000 kHz	1.55
Over most of band	better than	1.2

other bands

No readings are shown for 20, 15, and 10 meters because, on those bands, the VSWR will be reasonably low if the capacitor is simply tuned near maximum capacitance once and the antenna pruned as though the capacitor were not in use. If you want to go to the trouble of making the adjustments, though, the VSWR can be reduced to approximately 1.0 over these three bands by making use of the capacitor, as on 40 and 75 meters.

initial adjustments

The initial adjustment that has to be made only once (for each band on which you'll want to take advantage of the capabilities of the capacitor) is simple. It involves trimming the resonator whip length (in the case of a Hustler) or top hat capacitance to the value that gives equal VSWR readings at the band edges when the capacitor is rotated for minimum VSWR. With the 40-meter Hustler resonator, for example, this will involve lengthening the whip perhaps 3 inches (7.6 cm) from the normal midband setting. Once this is done, a VSWR meter is no longer essential, as long as you stay within the band limits, because proper setting of the capacitor can be made simply by tuning for maximum output, as noted elsewhere.

On 75 meters, my 75-meter Hustler resonator "just barely got there" before running out of resonator tip. So I attached a miniature hose clamp above the coil to the top of the fat part of the top section, with the free end of the clamp (about 1-1/2 inches, or 3.8 cm) providing some additional capacitance. While minor adjustments may have to be made to accommodate the variable capacitor, planetary drive, and the limber shaft to a particular car, the considerations will be generally the same.

The best place for the antenna is as *far back* on the left rear fender as possible; or, if you don't want to drill a hole for the ball mount, place it on the left side of the bumper using a bumper mount.

precautions

It's extremely important that a bumper mount be jumpered as directly as possible to the sheet metal of the car body with two separate, flat braids at least 1/2 inch (12.7 mm) wide, terminating at points about 12 inches (30 cm) apart. Drill pilot holes for sheet-metal screws if there are no suitable points of attachment. This is especially important with the new bumpers, like those on my car.

The ball mount (or bumper mount and braid terminations), the tuning capacitor, and the planetary drive unit must *all* be clustered close together, with minimum bend in the limber shaft drive. Some bending of the shaft can be tolerated, as long as it doesn't make too sharp a bend radius anywhere along its length. In my car, the *capacitor* is mounted on a horizontal and flat section of the fiberboard trunk liner, where it houses the connections to the left-hand stop, turn, tail, and back-up lights. Capacitor frame must be floated.

some final observations

Tuning for maximum power output with a VSWR box is simple if you're parked. But reaching around to tweak the tuning knob, while mentally subtracting the reflected power reading from the forward power reading, is definitely not recommended as something to be accomplished while in traffic. Tuning for maximum output on a single meter at eye level is much quicker and safer. However, you should first make sure that the MAX INDICATOR peak correlates reasonably well with maximum *radiated* power.

In a mobile installation there often are strange currents flowing in the car metal. "Wattless" displacement currents that unintentionally get coupled into a sampling antenna or pickup loop *can* upset the accuracy of the reading insofar as correlation with the actual radiation well beyond the induction field. At first I obtained an appreciable discrepancy when tuning for maximum "net" power on the VSWR box then peaking the reading obtained with the 1N34 sampler previously described. I found that very effective rf filtering was required on the wire bringing the rectified dc to the driver's position. Also, correlation was better when the very small pickup loop was placed right against the lead between the tuning capacitor and antenna base, rather than the lead between the coax and the capacitor. A larger link spaced from the lead caused some problems with stray fields.

To make absolutely sure that the maximum "net" reading on the VSWR box correlated with maximum *radiated* power, I took field-strength readings at 75 feet (23 meters) through a target spotting scope. The car was parked in a vacant parking lot, with no wires between the field-strength meter and the car.

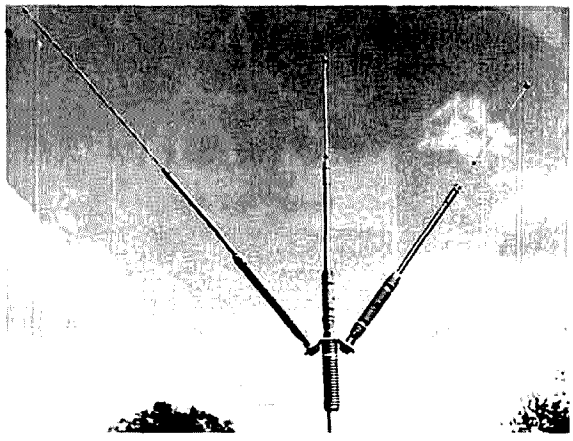
Correlation between field-strength peak readings and readings on the tune-for-max indicator was, for practical purposes, 100 percent after changes were made in the sampling loop (link) position; one side of the link was grounded *at the link* and filtering of the 1N34A dc lead was improved.

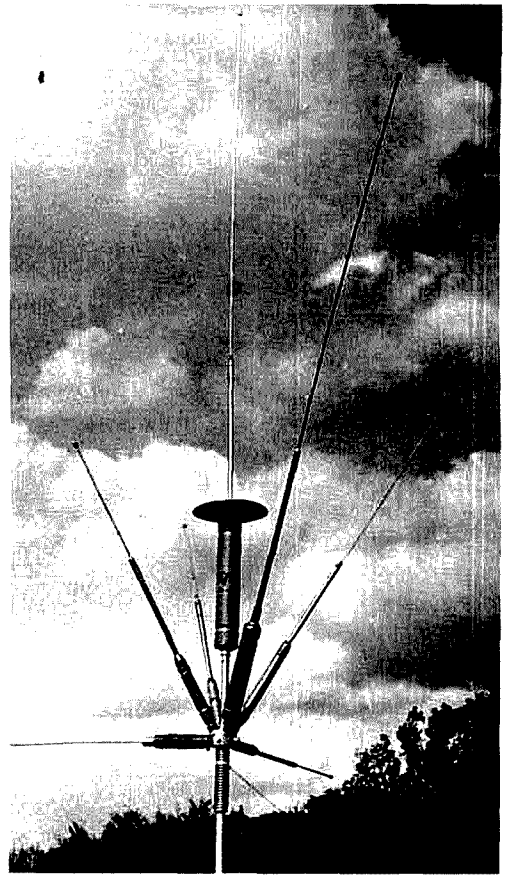
When you get your "world's simplest mobile antenna tuner" installed and ready to go, first make sure your "output power peaker" (if you use one) correlates reasonably well with the *net* readings of the forward and reverse power readings on a VSWR meter. Then you can forget the entire VSWR hassle and tune for MAX, which is more fun than tuning for a dip.

ham radio

Modifications to a popular mobile antenna for multiband operation

Nine-resonator antenna with seven resonators in place (right). Those for 10, 15, 20, 40, and 80 meters are pointing upward. The two horizontal elements are for the new WARC 10-18 MHz bands. Below, complete assembly of the three-band antenna.





refinements to a mobile high-frequency antenna

Ten **months to retirement!** During the countdown, all my free time was devoted to getting a mobile CW station working in my car. No way would I go on an extended trip without ham radio. An FT 101-B would be my transceiver, and for the radiator I chose the Hustler mobile antenna. I had been going to roll my own, but time was running out.

At first I purchased only the 40-meter resonator with the antenna and mount. This gave me a chance to run some tests and determine the capabilities of such a short antenna mounted on the bumper of the car. Fig. 1 shows the original installation. The results amazed me! In a few days I worked WAC on 7 MHz from the highways in eastern Pennsylvania. This mobile operating opened up a new dimension for me. I then purchased the four other resonators, tuned them up, and off we went on a two-week trip to Florida. I had more fun working mobile than sightseeing.

During a memorable QSO on 21 MHz, the DX station informed me that 28 MHz was wide open, and he asked me to change frequency, as we needed to make contact only on 10 to complete a five-band exchange. This band change required stopping the

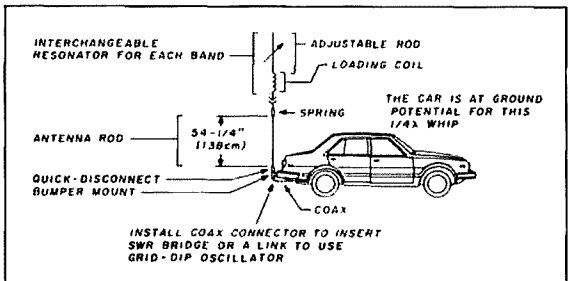
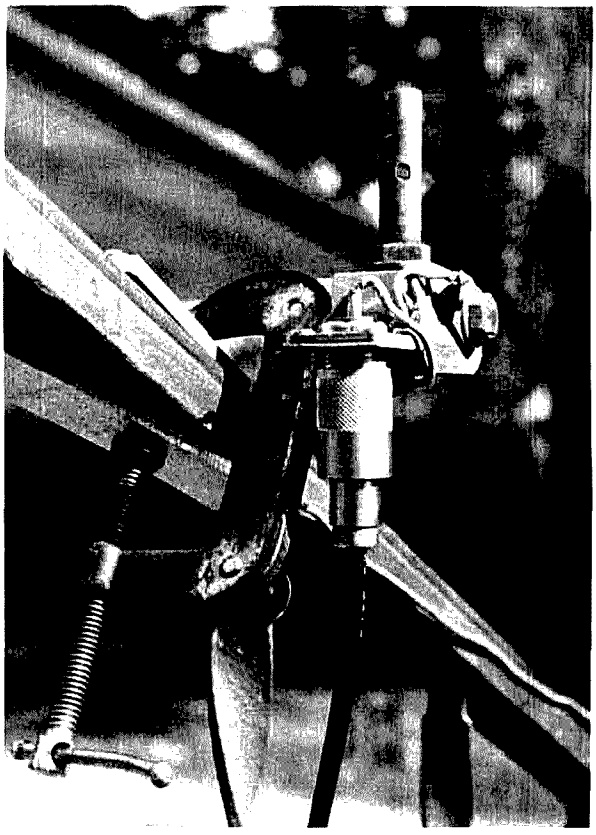


fig. 1. Author's original mobile installation showing bumper-mounted Hustler antenna. Quick disconnect allows easy insertion of test equipment.

By Frederick Hauff, W3NZ, 437 South Lewis Road, Royersford, Pennsylvania 19468



Universal C-clamp mount for the nine-resonator mobile antenna. (The male half of a quick disconnect points up.) Small aluminum pads 1/8-inch (3-mm) thick are installed on each side of railing. Screws in C clamp are for connecting radials.

car, unscrewing the 15-meter *resonator*, and putting the 10-meter resonator in place. It's not much of an operation, but it was raining. Full of true ham spirit, I made the band change. The contact was completed on 10 meters, which gave me great satisfaction.

This one band change convinced me that all was not ideal with the original setup. Some changes would have to be made if I were to come up with a mobile multiband antenna. This could be a nifty retirement project. I had a feeling that several resonators could be connected together at the bottom end. Here's how I did it.

three-band design

Fig. 2 shows a small bracket that holds three resonators at the same time and reduces their mutual inductive coupling. The 15/10/20 meter resonators were assembled as shown. A Jones Micromatch (SWR bridge) was installed into the feed line. Only a slight adjustment was needed to bring the SWR on the three bands to 1.1 or better. **Table 1** shows the length of the tuning stubs measured from the very end to the end of the locking nut.

table 1. Lengths of elements for the three high-frequency bands measured from element end to locking nut.

	amateur band (MHz)		
	28	21	14
single resonator at end of antenna, inches (mm)	7-5/16 (186)	8 (203)	14 (356)
three resonators mounted for three-band operation, inches (mm)	6-1/2 (165)	7-5/8 (194)	13 (330)

I made field-strength measurements on 28 MHz with all three resonators in place, then with only the 28-MHz resonator in place. I detected no change in field strength. But then a friend asked, "What are you going to do about 40 and 80, and what about the new WARC bands?"

nine-resonator design

After a few days in my workshop I came up with a new creation. **Fig. 3** shows the details of a new, lightweight, low-profile adapter that will accept a total of nine resonators. It was made up by using only a small bench lathe and a drill press.

Fig. 4 shows the arrangement of the resonators, including the change in length of the tuning stub. I omitted the 80-meter setup since I could purchase

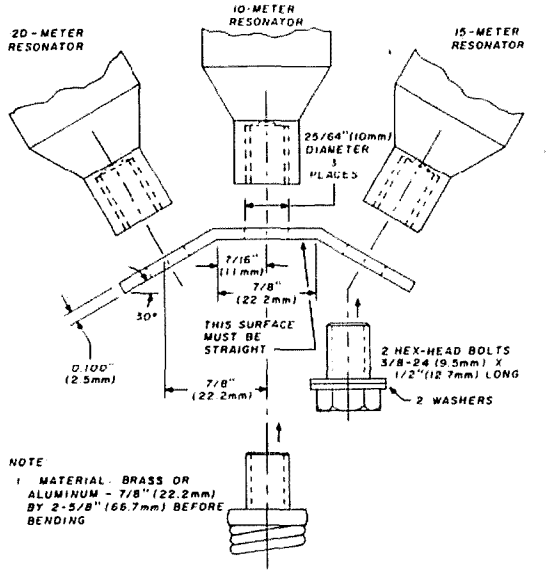


fig. 2. Three-band mobile antenna showing adapter bracket to hold three resonators to the antenna rod (whip) of *fig. 1*.

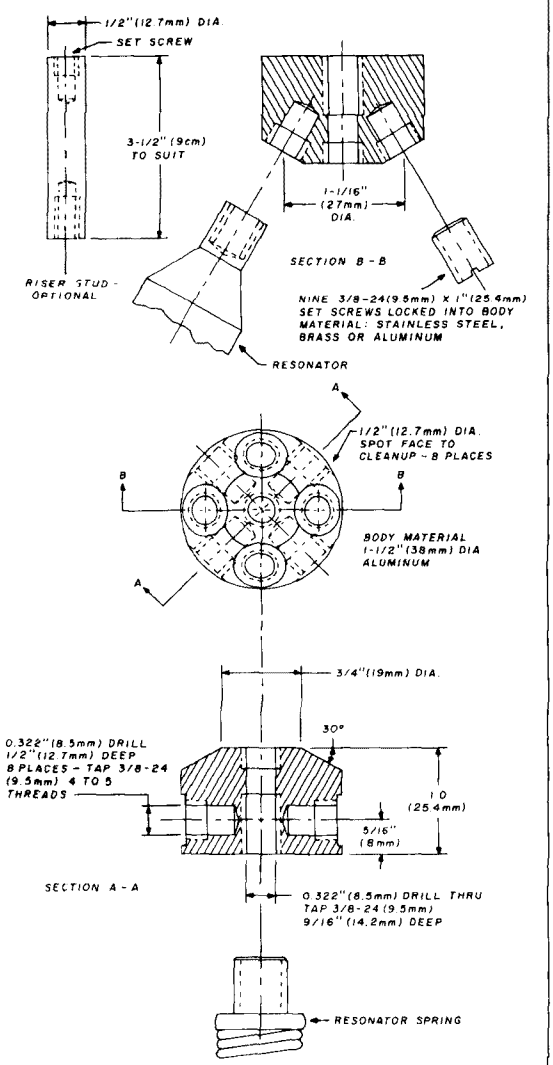
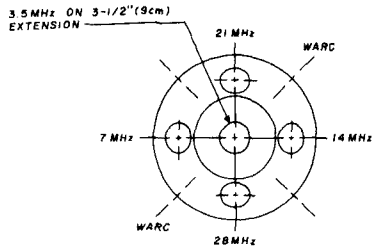


fig. 3. Mechanical details for constructing a nine-resonator adapter.



	AMATEUR BAND (MHz)			
	28	21	14	7
SINGLE RESONATOR, INCHES (mm)	7-5/16 (186)	8 (203)	14 (356)	23-1/2 (597)
FIVE RESONATORS ON ADAPTER, INCHES (mm)	6-1/2 (165)	7-1/2 (190)	12-3/4 (324)	20-5/8 (324)

fig. 4. Arrangement of the different resonators. Table shows lengths of the elements when using a single resonator and when using the resonators and the adapter.

only the resonator for the 75-meter phone band and had to improvise to work on the low end of 80 meters to bring the resonator to frequency. I also installed a disk 4 inches (10 cm) in diameter above the 80-meter loading coil to improve the SWR and also to reduce the length of the tuning stub. The SWR for all five bands is better than 1.15:1.

There is no guarantee that the resonators for the new bands will perform in conjunction with the present-band resonators. There might be too much interaction between some of the loading coils. At one time, I installed two 40-meter resonators. I wanted one tuned to 7025 kHz and the other to 7225 kHz. However, I never was able to accomplish this.

160-meter mobile antenna

It was impossible for me to purchase a resonator for the 160-meter band. I either had to make one myself or just forget about 160-meter operation from the car. I not only wanted to work 160, but was also curious to see what could be done on that band while rolling along. **Fig. 5** shows the details of my 160-meter loading coil. Many experts will have misgivings about using PVC tubing. Since I had nothing else, I tried it, and it has been working just great with the FT 101-B; no breakdowns!

An old telescoping automobile antenna serves as tuning stub, with an aluminum disk 7 inches (18 cm) in diameter between the tuning stub and loading coil.

The adjustment on 160 meters must be precise: usable bandwidth is only 6 kHz. For 1805 kHz, my tuning stub is adjusted to a length of 44-1/8 inches (112 cm) from the coil to the end of the stub.

notes on the directivity of the antenna

While in Florida, I had biweekly schedules with N3WW (distance 1,000 miles). I always had the rear of the car facing toward Pennsylvania. (The antenna is mounted on the rear bumper). We always managed our CW contacts, but at times copy was marginal. One morning a side road was blocked off and I had to

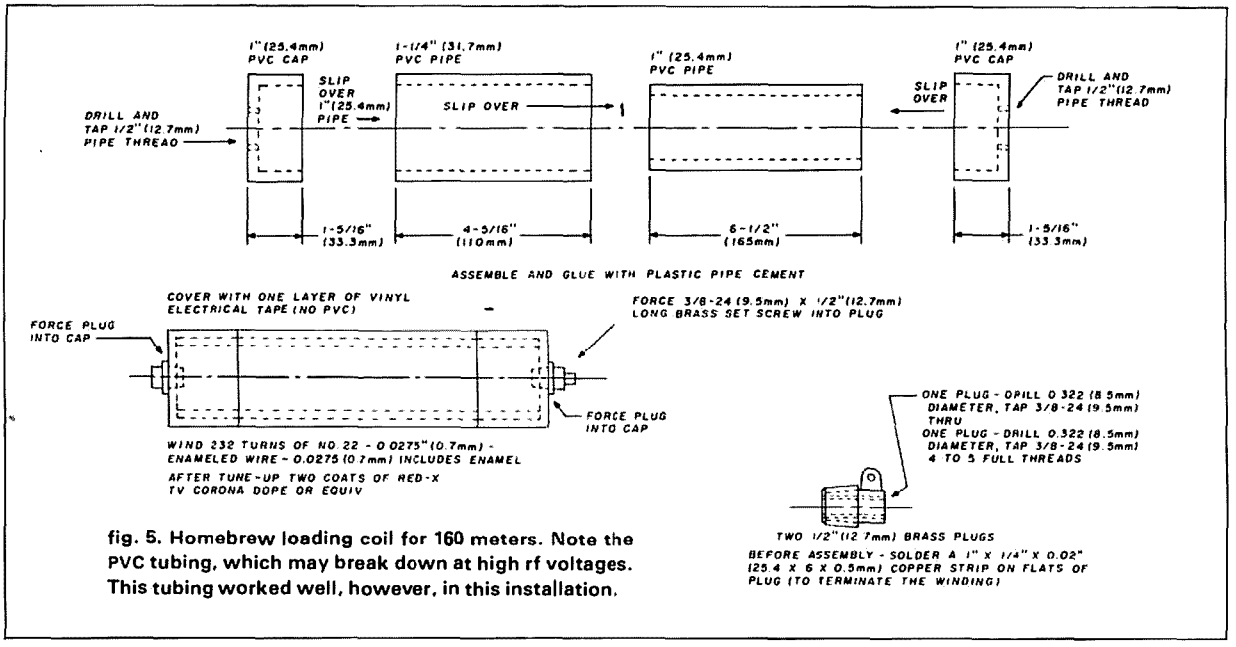


fig. 5. Homebrew loading coil for 160 meters. Note the PVC tubing, which may break down at high rf voltages. This tubing worked well, however, in this installation.

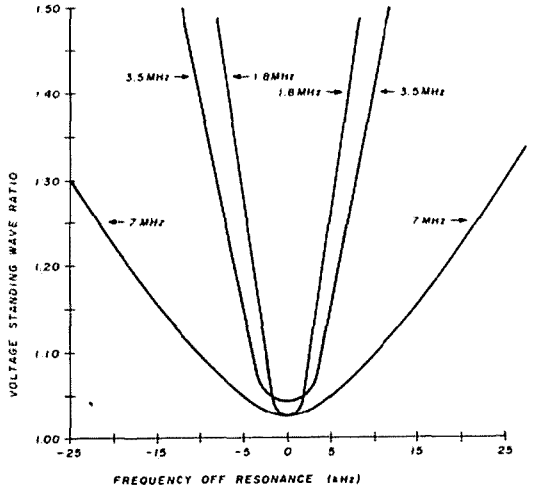
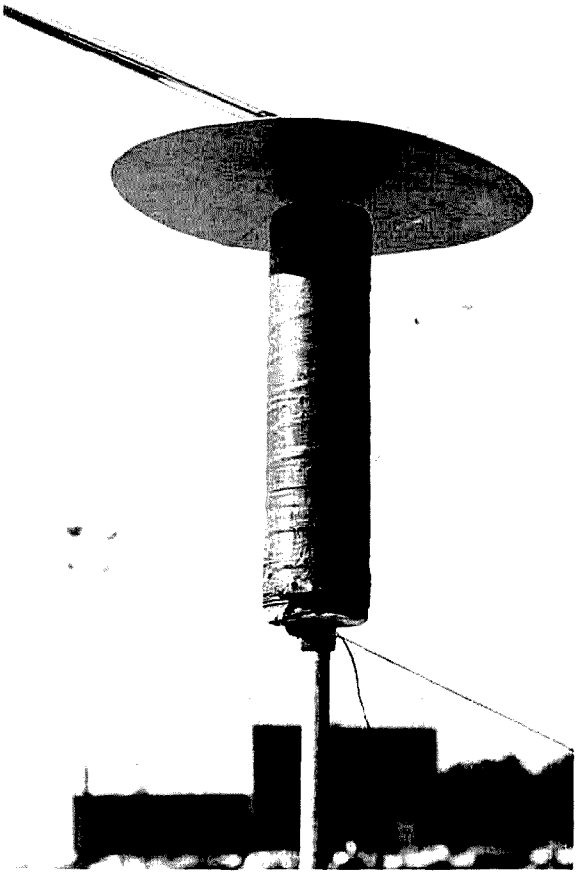


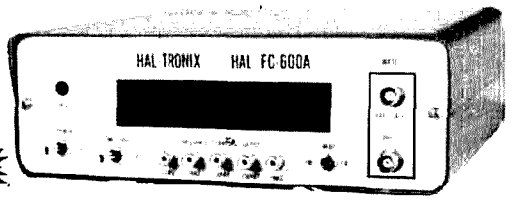
fig. 6. Plot of standing-wave ratio as a function of off-resonance frequency for three bands. Plot for the 160-meter antenna was made separately. Not bad considering the mechanical constraints involved.

make a U turn. I was amazed! The signal from N3WW went from S5 to 20 dB over S9. N3WW started to ask questions about the tremendous increase in signal strength. I made a few more circles with the car. The results were always the same: maximum signal when the front of the car was facing in the direction I was working.



The 160-meter loading coil with 7-inch (18-cm) diameter disk. Tuning stub at top of disk is used to reduce the total height of the antenna to 10 feet (3 meters).

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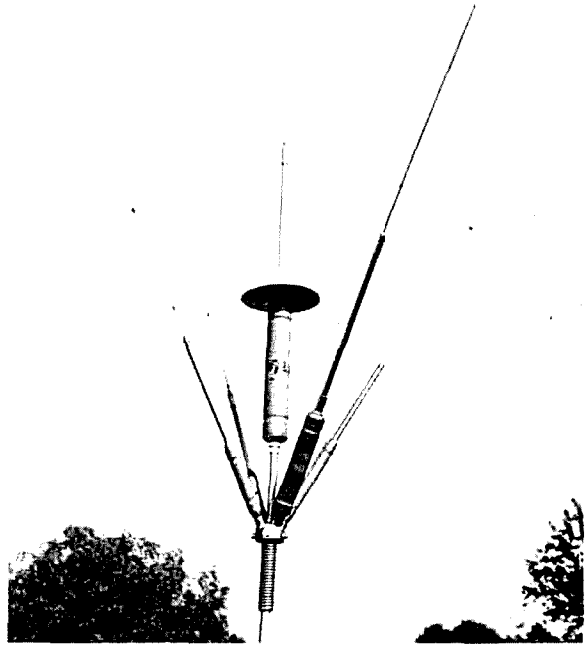
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Ready to roll with the five-band mobile antenna. (All resonators tuned to 25 kHz from the low ends of the bands: 10, 15, 20, 40, and 80 meters.)

We made the same tests on 21 MHz. The results were more pronounced: from S5 to 30 dB over S9.

The very same evening we met on 7 MHz and obtained similar results. However, the difference in signal strength was only 2-1/2 S units, and on 80 meters the difference was 1 S unit.

I ran a few tests with some DX stations (3000+ miles). The difference in signal strength was not nearly as spectacular, but a difference was noted.

Every time I now work mobile I feel that I am sitting inside a good beam antenna. I hope I never get carried away and make a U turn on a freeway.

Can anything be worked mobiling on 160? During the 160-meter ARRL contest I was on the beach at Daytona Beach, Florida. In 45 minutes I worked 35 stations. Enough said!

Fig. 6 shows SWR versus frequency for three bands. I had no desire to try the 160-meter antenna in conjunction with any of the others; it's big enough by itself!

No one should have to stay off the air for lack of an antenna. The photo shows a forged C clamp that can be used in various places and situations; for example, on a railing, picnic table, fire escape, rain gutter. However, an effective ground should be provided.

I wish all of you happy mobiling! At least five bands are available by the flip of the radio's bandswitch.

ham radio

ham radio TECHNIQUES

Bill Orr W6SAI

One-sixty meters is Amateur Radio's grandpa band. This band is where it all started after the experts said that wavelengths below the broadcast band (short waves) were useless for radio communications. But the hams proved otherwise. And now, many years after Amateur Radio pioneered shortwave communications, 160 meters is still flourishing. It is the *elite* ham band. Working on 160 meters requires a special kind of discipline. And there's a gentleman's agreement about operating practices that's not evident in the higher-frequency (shorter wavelength) Amateur bands. Operating on "top band" is a real challenge.

In this month's article, pioneer Bill Orr tells how to make a simple but effective transmitter for 160 meters that will provide many hours of enjoyment – easy to build and easy to get going. **Editor**

The year 1933 was a harsh one for most Americans. The economy was in a shambles. The discredited Administration had been swept out of office in the 1932 election landslide, and there was an ominous pause in the heartbeat of America before the new President took office in March of 1933. The economic clock of the country had run down.

Between the crash of 1929 and the new year of 1933, the economy had gone from bad to worse. Business was at a standstill. Unemployment ran as high as sixty percent in some cities. Hordes of men and boys roamed the countryside, looking for work or a handout. The Southern Pacific Railroad testified before Congress that it had thrown more than 680,000 vagrants off freight trains during 1932.

Those lucky enough to have a job during these hard times had little, if any, money left over for pleasure or amusement. Jobs were scarce and low paying. An offer of 20 dollars a week, or even 30 cents an hour, was enough to create a long line of job hunters. Lucky kids got an allowance of ten cents a week. Apartments rented for 20 dollars a month, movie admission was 15 to 25 cents, with kids at 10 cents. And a good hotel room was $4.50 a day.

Viewed by today's standards, 1933 was a very different time. There were no copying machines, clock radios, ball-point pens, televisions, automatic dishwashers, or zip codes – and only a few electric refrigerators. Amateur Radio was blissfully unaware of single sideband, SWR meters, DXCC, slow-scan television, transceivers, beam antennas, and all the other goodies of modern communications that we take for granted today.

It wasn't easy to buy ham gear in 1933. The market was small, and not many stores or manufacturers catered to Amateur Radio enthusiasts. The prices of receivers and components were astronomical despite the depression. Bearing in mind that the 1933 dollar had about ten times the purchasing power of today's dollar, prices of ham equipment were staggering, especially to the unemployed Amateur.

getting on the air in 1933

Many hams were not on the air, because it was an expensive and time-consuming chore. Paradoxically, this was a period of great growth in Amateur Radio. The number of licensed Amateurs exploded, almost doubling between 1932 and 1934. Perhaps this was a result of there being many people with plenty of time on their hands, or a result of the demise of the broadcast-receiver-building boom, which all but ended with the introduction of the all-ac-operated receiver – who knows? In any event, the pressing problem was how to get on the air with a thin purse.

Other factors complicated the problem. Buying on credit was almost unknown. Radio equipment was sold strictly on a cash-and-carry basis. There were no credit cards, no 800 phone numbers, and little manufactured ham gear. Amateurs, in fact, took pride in homemade stations; and the rare, affluent Amateur with "store bought" equipment was viewed as something of an eccentric.

Nevertheless, by the time his ham license came in the mail from the Federal Radio Commission (the grandfather of the FCC), the would-be Amateur probably had a two-tube regenerative receiver set ready to go

for ham work. The transmitter, unfortunately, was more of a problem.

The solution was to build a simple transmitter out of readily available parts from defunct battery-radio receivers. Old five-tube, battery-operated, receiver chassis could be obtained on "radio row" in most cities for twenty-five or fifty cents, often complete with tubes. Armed with one or two old receivers, the new ham was ready to begin building a transmitter from the components. If the components were not just right, he could swap them with other money-short Amateurs to try and get what he needed.

what to build? what band to choose?

Once a junkbox of parts was at hand, the next problem was to determine the band of operation and the transmitter circuit. Bandswitching transmitters were unknown, and band changing, attempted by the more sophisticated Amateurs, required a basket-full of plug-in coils. Most Amateurs stayed on one band for a long period of time because economics forced them to do it. These fellows depended on *QST* for ideas.

Ten meters was an unknown quantity; fifteen meters did not exist. It was difficult to get a transmitter to work on a frequency as high as 20 meters, and many would-be DXers gave up in disgust. *QRM* was heavy on 40 meters (strictly a CW band — no phone allowed). And 80 meters was chock full of traffic nets. Indeed, the greatest portion of Amateur activity was on the 80-meter band.

That left 160 meters. And this was *the* popular beginner's band and the home of the inexpensive, home-built station. Many beginners opted for 160 meters, and spent their formative years on this band.

The CW portion of the 160-meter band extended from 1715 kHz to 1800 kHz. Canadian phones occupied the portion from about 1770 kHz to 1800 kHz, and that left a nice, 55-kHz-wide band segment open to CW operation, with little QRM. And on a good night, contacts up to 500 miles or more were possible.

let's build a replica transmitter

Several circuits were at hand that would work. The proven Hartley, and the TNT (tuned, not tuned) circuits were good ones. But a newer, more simplified design was gaining popularity: the unity-coupled Hartley oscillator (**fig. 1**). This simple circuit used two receiving-type tubes in push-pull and two or three fixed capacitors and resistors. The whole works could be built on a breadboard in a few hours. The two 245 receiving tubes* could be operated at up to 400 volts at 100 milliamperes, providing a respectable 40 watts input and an output of about 20 watts. That's plenty of power to work a lot of DX.

Construction information on this interesting transmitter appeared in the August, 1933, issue of *QST* magazine. Since most new hams didn't have the $2.50 for an ARRL membership (which included *QST*), they either bought a copy (25 cents) at the local magazine and cigar store or got a penciled sketch of the schematic from a friend.

The transmitter is built on a breadboard measuring 9 inches wide and 10 inches deep (23 × 25 cm). Since breadboards, as such, are now nearly defunct, you can build your replica on a piece of plywood or shelving. The

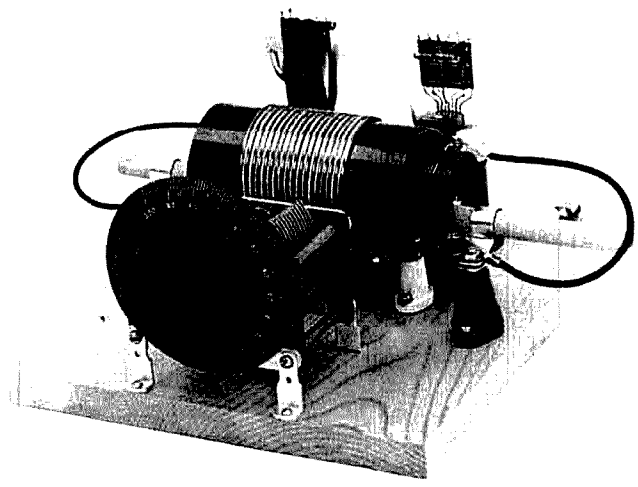
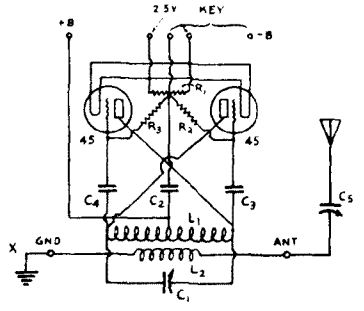


fig. 1. A 1981 replica of a 1933 transmitter. This little 40-watt oscillator provides a clean CW signal for 160-meter operation. It is built upon a "breadboard" in the true tradition of yesterday. The frequency-setting capacitor and dial are in the foreground; the oscillator tank coil is directly behind it. This coil is wound with enamel wire, slightly spaced by winding string between the turns. The coil is given a spray coat of air-dry plastic cement. Note that the string is left in the winding.

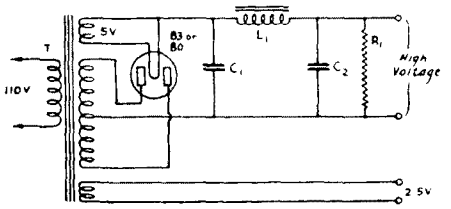
The antenna coil is wound on a smaller-diameter Bakelite (phenolic) tube attached to a dowel rod. The rod is mounted in clamps affixed to insulators. This arrangement permits the coupling between the coils to be adjusted for best oscillator performance. Tube sockets and grid capacitors are mounted to the rear of the breadboard.

*The UX245 triode was used in the audio amplifier circuit of many broadcast receivers. They provided the nucleus of many early Amateur shortwave transmitters. If you were able to scrounge a type UX210, then your ham rig could run even higher power — provided you had higher plate voltage. **Editor**



— THE PUSH-PULL SERIES FEED HARTLEY CIRCUIT USED IN THE 1750-KC. TRANSMITTER

C_1 — 500-μμfd. variable condenser (Cardwell 123-B).
C_2 — .002-μfd. mica condenser (Aerovox Type 1450).
C_3, C_4 — .0001-μfd. mica condensers (Aerovox Type 1450).
C — 250-500-μμfd. variable condenser, any type.
R_1 — 20-ohm center-tapped resistor.
R_2, R_3 — 100,000-ohm, 2 watt resistors, non-inductive (I.R.C.).
L_1 — 22 turns No. 12 enamelled wire on 2½ inch bakelite tube; turns spaced with string to make length of winding 2½ inches.
L_2 — 20 turns No. 16 enamelled wire on 1½-inch bakelite tube; no spacing between turns.



— SUGGESTED POWER SUPPLY CIRCUIT

T — Receiver power pack transformer delivering 2.5 volts at 3 or more amps., 5 volts for rectifier tube, and having a high-voltage winding for 350 volts each side center tap.
L_1 — 30-henry, 100-ma. filter choke.
C_1, C_2 — 8-μfd. 500-volt electrolytic condensers.
R_1 — 25,000-ohm, 25-watt resistor.

fig. 2. Schematic diagrams of the original 1933 transmitter. The 1981 version has only 18 turns in the tank coil to move the operating frequency from 1750 kHz to 1800 kHz. A regulated power supply is suggested instead of the capacitor-input supply shown. (Circuits from *QST* magazine.)

board is given a few coats of shellac or varnish before work is started.

The tuning capacitor and tank coil, the heart of the oscillator, are mounted at the center of the board, with the two tubes mounted immediately to the rear. The schematic diagram (**fig. 2**) is arranged somewhat in the same manner in which the components are mounted to the board. Notice that the circuit is push-pull, with the grids cross-connected to the plates of each tube. When the circuit is oscillating, the peak grid voltage of one tube will be equal to the peak plate voltage of the other. Since the 245 triode tubes have a very low amplification factor (3.5), this provides just about the right arrangement for Class-C service — the grid swing being equal to the plate swing over the operating cycle.

Grid excitation is controlled to a degree by the small size of the grid-coupling capacitors, which form an rf voltage divider when considered in conjunction with the grid resistors. In any event, it all works smoothly, and the circuit is a steady, reliable oscillator.

the tank coil

The tank coil is wound with No. 12 (2.1 mm) wire, as it carries high circulating current in this high-C oscillator circuit. The antenna coil, which is somewhat smaller in diameter, slides in and out of the tank coil, supported on a wooden dowel rod affixed to two standoff insulators.

Variable coupling is achieved by sliding the antenna coil back and forth until proper antenna loading is achieved, in the manner of the pre-World War I "loose couplers." The dowel rod slides back and forth in small clamps made from thin aluminum stock; the clamps are bolted to the authentic, brown standoff insulators. The antenna coil is bolted to the dowel rod, and connections between the coil and the insulators (which also serve as connections for antenna and ground) are made with flexible wire, normally used for test leads.

the antenna — tuning up

The 1933-type antenna works just as well today as it did then — a simple Marconi of about 120 feet (37 meters) working against a good ground.

To get things going, the transmitter requires a filament supply of 2.5 volts ac at 3 amperes. The plate supply may be anything between 300 and 400 volts dc at 100 mA, well regulated. A voltage-regulated supply will be helpful in obtaining a good CW note from this simple transmitter.

The frequency is set within the band with the aid of an external monitor receiver, with the plate-tank tuning capacitor being about 75 percent meshed. Antenna coupling is loose; that is, the coil is pulled out as far as it will go. The antenna is then tuned to resonance, as noted by 1) a change in oscillator plate current (which is running quite low), and 2) a change in frequency, as noted in the monitor receiver. Antenna coupling is increased (with a corresponding increase in plate current) to provide the greatest power output consistent with good frequency stability under keying. It's not hard to reach a compromise, with plate current running 80 to 100 mA.

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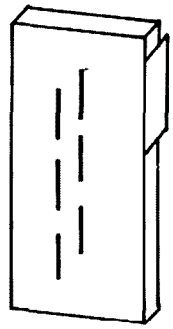
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One point should be noted: the oscillator is directly coupled to the antenna and an antenna swinging in the breeze will cause the note of the little transmitter to waver a bit. Loose coupling to the antenna helps eliminate this annoying problem.

getting on the air

Now that you have built your replica of the 1933 transmitter what can you do with it? Easy! Work stations! The CW segment of the 160-meter band runs from 1800 kHz to about 1820 kHz, with some CW activity in other portions of the band, depending upon the geographical division of the band: see the *ARRL Handbook* for details. Operation close to a band edge *is not* recommended unless the frequency is *carefully monitored.*

But you can work plenty of stations with this midget transmitter. Most modern hams will express a sense of awe and amazement at working a 1933-style, breadboard transmitter. But not one in ten will guess it from the CW note this little transmitter puts out. And, even if you don't put it on the air, it certainly is an interesting conversation piece, worthy of a place of honor in your radio shack!

old-time radio equipment

A growing number of today's Amateurs are taking a great interest in old-time Amateur gear. Old radio magazines are a treasure trove of circuits and information. Old tubes and components (while not available at the corner *Radio Shack*) can usually be picked up at flea markets and from older Amateurs who still maintain a junkbox. Compared with today's equipment, the old circuits are simple and straightforward.

It's fun to build up the old gear and get it on the air, and various contests take place from time to time based on the use of home-built replicas of yesterday's equipment.

Want more information? I suggest you write to the Antique Wireless Association for details: Bruce Kelley, W2ICE, Holcomb, New York 14469.

ham radio

the weekender



stabilizing the DenTron 160XV transverter

My DenTron 160XV Transverter sat quietly unused in a corner of the station for many months after I had bought it for a standby rig. One fine day I was conned into a 160-meter schedule without my main rig for 160, since it had been borrowed by the ham who made the schedule. On tuneup, the DenTron had a plate current peak instead of the traditional dip (anyone remember tubes?). Worse, severe distortion showed on the scope and on the air. When the set was in the bypass position and the relay keyed, even with no drive applied, bright arcs flew across the plate tuning capacitor. These are all symptoms of self-oscillation — positive feedback.

I had noticed similar symptoms some years ago with another 160XV. A call to the factory implicated C15 and C16, 0.01-μF and 150-pF capacitors respectively, as occasionally subject to breakdown. These two large disc ceramic capacitors, which couple the output of the 6146B to the pi network, are located on the printed circuit board just about under the large air-wound coil, L9, and just to the left of two runs of small coaxial cable, when looking at the set with the front panel facing you. Replacing these didn't solve my problem, but it's worth a try, as failure of the capacitors could cause stability problems.

By Peter Ferrand, WB2QLL, 355 Lake Street, Nashua, New Hampshire 03060

A close inspection of the physical layout of the output circuit proved more rewarding. From the top of the 6146B plate choke the output rf is carried down a piece of bare wire to the circuit board, where it runs on a trace to C15 and the pi network. The problem is that this trace is less than 0.1 inch (3 mm) away from the grid-circuit trace. It turns out that coupling occurs across the two nearly parallel traces, with a consequent tendency toward self-oscillation.

The fix is very simple. Unsolder the circuit board end of the vertical bare wire next to the 6146B (and its plate choke) and swing the free end around the choke in a counter clockwise direction, until it is between C15 and C16. Then remove C15, the 0.15-μF, 1.6-kV capacitor, and solder one end of it *above the board* to the same side of C16, the 150-pF, 4-kV capacitor to which it had been connected below the board. Then solder the free end of C15 to the free end of the bare wire you unsoldered previously. What you have achieved is to redirect the rf output away from the grid circuit around the 6146B socket; the circuit itself remains unchanged.

Next we go back to the bottom of the board, to the trace to which C15 had been connected, and tie it to ground as a partial shield. Solder a wire from the trace (identified on my unit with a "J") to the nearest handy ground, pin 2 of the 6146B. While we're at the 6146 note that the tube's filament is not bypassed. I didn't notice any difference, but on general principles connect a 0.01-μF capacitor from pin 7 to the ground foil.

That's about all there is to it. The transverter will now put out its 70 watts. Turning the plate tuning control will produce a plate current dip simultaneously with output power peak, with no arcs or sparks. You have created stability in an unstable world.

ham radio



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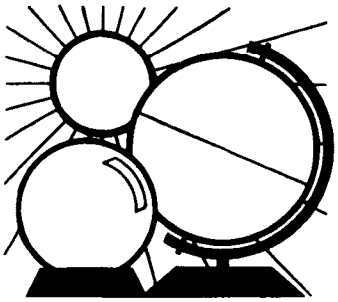
ham radio readers' survey

Here's your chance to get into the act and help shape the destiny of *ham radio* magazine. It's been six months since we started publishing the new *ham radio* incorporating Ham Radio HORIZONS. We've made a lot of changes. How do you like them?

We've made these changes in an effort to satisfy our former HORIZONS readers and also to include suggestions we've received in recent years from our *ham radio* readers. We've read your letters and talked to hundreds of you at various hamfests. Are we heading in the right direction? We think so, but we must know for sure. So here's a little questionnaire that will give you a chance to tell us what you like, and dislike, about the new *ham radio*.

It's not often you get a chance to tell magazine folks what they're doing right and what they're doing wrong. So please take a few minutes and fill out the questionnaire. If you'd rather not remove a page from your magazine, just send us an SASE and we'll ship you a page by return mail.

We've been doing our best to bring you the very finest magazine in its field. Now it's your turn to tell us what *you* think. If you'd like to add your own comments, just jot them down on a separate sheet of paper and send them in.



DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

The lower-frequency bands are expected to be favored for DX during the first week of the month if the summer QRN isn't too bad by then. DX conditions for the higher-frequency bands should improve by mid month, decrease until about the 24th, then increase somewhat toward the end of the month in time for field day. Propagation disturbances are expected around the 6th and 18th. The first disturbance may bring DX from unusual locations on the lower frequencies in east-west directions, while the latter disturbance may show good one-hop trans-equatorial openings on the higher bands.

Lunar perigee comes twice this month, on the 2nd and 30th, and the full moon on the 17th. The longest day of the year, summer solstice, is on the 21st at 1145 GMT and begins our summer season. It also ushers in the sporadic-E season in full swing to make the short-skip openings the rule rather than the exception (see last month's DX Forecaster).

DX conditions during summer are usually not as good as those during other seasons of the year because of propagated static noise from evening thunderstorms on the lower-frequency bands. The higher-frequency bands have lower maximum usable frequencies (no 6-meter, F-region-propagated openings). This is somewhat compensated for by having more hours for operating becoming available because of longer daylight, and also by openings from sporadic-E. Sporadic-E openings often occur on 6 meters and once in a while on 2 meters. This keeps life interesting.

some shop talk

The accuracy of forecasting and predictions is inversely related to the length of time in advance that the forecast or prediction is made or desired. Those that are made a long time in advance are generally known as predictions and are based on a reasonably accurate sunspot number for the year and season. They are usually made with the help of a computer. This enables one to sample the stored ionospheric information to find the maximum usable frequencies and propagated signal strengths by use of simplified radio-wave tracing techniques. The time scale here is on the order of months or years in advance, and the data are used mainly by engineers to design equipment and antennas for transmitting between two points. The prediction tables and graphs in the ham magazines are usually done this way because of the long publication lead times. For more detailed information see *ham radio* for April and September 1979.

Forecasting techniques are more akin to weather forecasting. They run from the present into the next few hours or days in advance. Forecasting is a way of updating the prediction method in a day-by-day or even hour-by-hour dynamic fashion for better accuracy. More on this technique later.

band-by-band summary

Ten and fifteen meters should give excellent daytime openings to most worldwide locations on both F-region long skip to 2500 miles (4000 km) and sporadic-E short skip to 1200 miles (2000 km) or multiples thereof on many days of the month. Don't expect as much one-hop trans-equatorial DX during disturbed periods this time of the year. June, July, and August are off-months for the F-region ionization to pile up on either side of the magnetic equator as it does from equinox through the winter to equinox. The ionization is down in the E region, making sporadic-E layers in the summer.

Twenty meters will be open to some area of the world for nearly all hours of the day and night. Sporadic-E propagation will fill in the pre-sunrise dip in usable frequencies during many mornings to make round-the-clock openings possible. The direction of the openings will not be much different than usual, and the openings will be extended in time.

Forty meters will give the best DX during the night from sunset until just after sunrise. Static levels may be high at times. Watch for local storm passages and operate near sporadic-E peaks around sunrise and sunset (particularly sunrise, when fewer thunderstorms have built up).

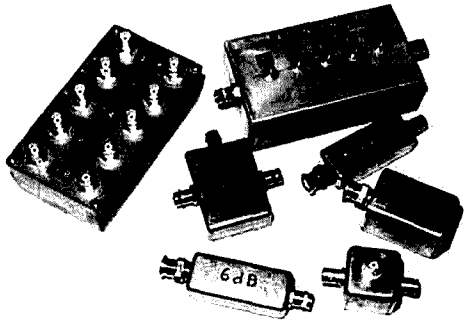
Eighty meters on some nights (during hours of darkness until sunrise) can have DX openings to areas of interest. Static from thunderstorm activity, long distance and local, may limit working the rare ones when propagation is otherwise right. Coastal stations usually have more favorable propagation geometry under summer conditions for working the rare DX than inland stations. Sporadic-E propagation around sunrise and sunset is good for this band also. Daytime work will be limited to within about 200 miles (360 km).

One-sixty-meter DX activities really require a lot of work this time of year. During hours of darkness between storm-front passages, you may work 1000 miles (1600 km) if your ears hold up. DX takes on a new meaning here unless you're really lucky. Nevertheless, you may want to give it a try.

ham radio

*Look at next **higher** band for possible openings.

GMT	PDT	WESTERN USA N	NE	E	SE	S	SW	W	NW	MDT	MID USA N	NE	E	SE	S	SW	W	NW	CDT	EDT	EASTERN USA N	NE	E	SE	S	SW	W	NW
0000	5:00	—	20*	20	15	15	10	10	—	6:00	15	15	15	15	15	10	15*	15	7:00	8:00	15	20*	20	10	20	15*	15	20*
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1100	4:00	20	—	—	40*	40	20	20	20	5:00	—	20	—	40	40	20	40*	40*	6:00	7:00	20	20	—	40	40	20	40*	20
1200	5:00	20	—	—	—	40	20	20	—	6:00	—	20	15	20	—	20	40*	40	7:00	8:00	20	15	—	20	—	20	20	20
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Accessories for use with the rf power meter.

rf power meter

Part 2: Measurements and measurement accessories

Part 1 of this article addressed the construction of an rf power meter capable of measuring amplitudes between −60 dBm and +20 dBm from 3.5 to 30 MHz. This rf power meter is the basis of a measurement system that can be used to make many useful network measurements, as explained in part 1. Some of these measurements are described in detail here.

accessories

Depending upon the measurement, various accessories are required, some of which you may have. Construction of others is covered in other literature sources, such as the *ARRL Handbook*[1] and *Solid-State Design for the Radio Amateur.*[2] I will list only the system components required to make the measurement and will describe the measurement itself. The photo shows accessories that I have built and found useful.

One accessory required for reflection measurements, as in measuring antenna VSWR and amplifier input VSWR, is a *directional bridge*. Hayward[2] briefly mentions the usefulness of such a device, but I haven't found many references that provide details on how to use it or what the limitations are in its use.

One of the advantages in using the bridge described here, as opposed to other "signal-separation" devices, is its simplicity, which results in the fact that it doesn't have to handle large amounts of transmitter power as in other coupler circuits found in SWR meters. This bridge is designed to be used with a low-level signal generator, VFO, or other oscillators delivering less than about +10 dBm (10 mV). Higher power will cause damage or may generate distortion, which could adversely affect the measurement.

directional bridge

The bridge is shown in fig. 1. Basically, it's a Wheatstone impedance bridge circuit with an unbalanced output to drive the power meter. Construction is uncomplicated. It should perform well up to and beyond 30 MHz with no adjustment or calibration. If your interests are limited to 30 MHz, no construction points are critical: simply use a reasonably close parts placement, high-quality components (small ¼-watt, film-type, 1 percent or better resistors preferred), and you should have no problems. If you anticipate working above 30 MHz, up to approximately 150 MHz, the bridge can be modified slightly to extend its range.

what's a network measurement?

Don't be concerned. You've probably been making them for a long time already but have been using other names such as VSWR or gain measurements. There are two basic types of network measurements that are made: transmission measurements and reflection measurements.

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In simple terms, we apply a stimulus signal, generally a low-level sine wave, sometimes swept, to the input of a one-port (antenna) or a two-port (amplifier) device, then we take measurements to see what is reflected from the input (reflection measurement), or what comes out of the output (transmission measurement).

Network measurements are, strictly speaking, linear measurements. That is, we measure the output at frequencies corresponding to the input frequency only. In many cases, however, we can look at nonlinear effects by changing our test procedure slightly and do things such as making an harmonic analysis of an amplifier. **Fig. 2** shows the two types of basic network measurements that can be made with the power meter and accessories. First, let's look at reflection measurements.

reflection measurements

The objective of a reflection measurement is to measure the amount of power reflected from a device, as shown in **fig. 3**. The reflected power is usually referenced to the incident power, and the ratio is expressed as VSWR, σ; reflection coefficient, ρ; or return loss, RL. These three quantities are all different ways of expressing the same thing; that is, how well the device is matched to the transmission line carrying the power. All three are scalar values; that is, magnitude only without phase angle. Any one of the three can be converted to the others using the expressions:

$$\rho = 10^{-\left(\frac{RL}{20}\right)} \quad (1)$$

and

$$\sigma = \frac{1+\rho}{1-\rho} \quad (2)$$

These equations are important since, as you will find, the measurement system described here measures directly in dB of return loss (the advantages will be discussed), which can then be converted to other units as desired. Antenna measurements, for example, are measured in return loss values, dB, which can then be converted into σ values to put them into a form in which they are usually expressed.

Most of us are used to thinking in terms of VSWR and will want to do this in other measurements as well. While you might object to the bother of converting from RL to σ, especially since SWR meters give this information directly, you'll find that the advantages of measuring RL far outweigh the minor inconveniences of conversion. And who knows, once you adapt to thinking in terms of RL, you may want to forget VSWR.

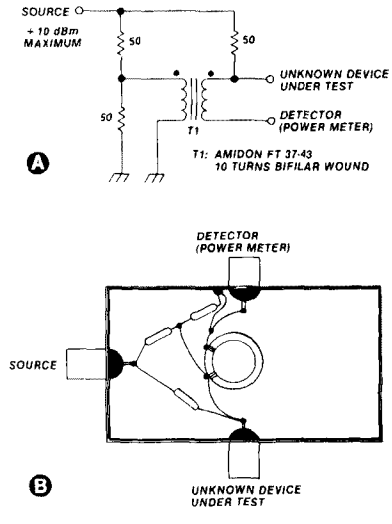


fig. 1. Directional bridge. The circuit (A) is basically a Wheatstone impedance bridge with an unbalanced output to drive the power meter. A suggested parts layout is shown in (B). Construction tips are given in the text.

making a return-loss (RL) measurement

A return-loss (RL) measurement is made in two steps: calibration and measurement. This measurement is analogous to an SWR meter measurement in which the meter sensitivity is adjusted to give a full-scale reading of the forward power (calibration), then switching to read the reverse power as a function of the forward power (the measurement) with a meter readout directly in VSWR.

As a specific example, suppose we want to measure the VSWR and bandwidth at the *VSWR = 3.0* points of our antenna. This measurement system is shown in **fig. 3**. Calibration is performed by connecting a standard (a known VSWR) to the unknown port of the directional bridge to establish the 0-dB relative reference level on the power meter. The absolute power is unimportant; it serves only as a level with which the subsequent measurement is compared.

The standard used is an open circuit with a VSWR of ∞, corresponding to a perfect reflection where all of the forward going power is reflected. (We would thus say that the open circuit had a 0-dB RL). Assuming that we had 0-dBm forward power, we would measure −6 dBm at the "detector" port of the bridge, corresponding to a 6-dB loss of the reverse power as it passed through the bridge to the "detector" port. A value of −6 dBm would then be our calibration value and should be logged or otherwise remembered.

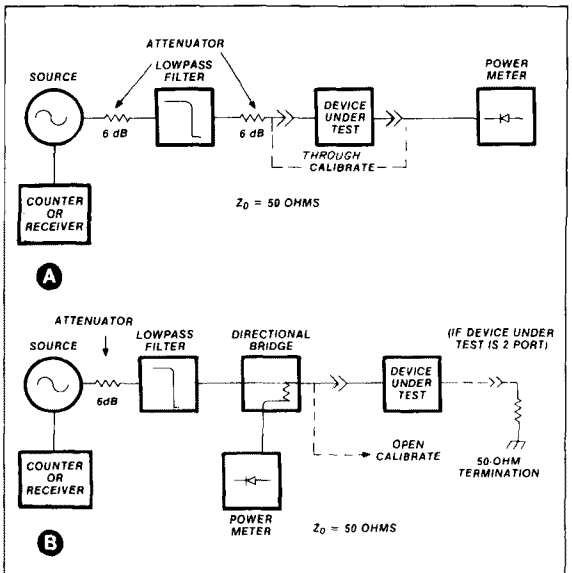


fig. 2. Instrumentation for basic network measurements. Transmission measurement setup is shown in (A); (B) shows instrumentation for reflection measurements.

With the antenna connected to the unknown port, a value is now measured that, when compared to the calibration level, −6 dBm, represents the return loss of the antenna in dB. If the power-meter reading were −15.6 dBm, for example, this would correspond to a 9.6 dB RL; 9.6 dB RL converts to a VSWR of 2.0, using the conversion equations. By tuning the source across the band you could then plot RL versus frequency and determine the *VSWR = 3.0* frequencies. Assuming the source were reasonably flat as you tuned, the calibration would remain good across the band.

why measure RL instead of VSWR directly?

There are three important reasons: resolution, accuracy and sensitivity.

Accuracy is determined to a large extent by how well you can read the meter or indicator, (scale resolution), and how well the directional bridge does its job (there are some other accuracy considerations that will be covered later). SWR meters, like the system described here, use some kind of signal-separation device (bridge, monimatch coupler). Therefore, other things being equal, they perform equally well in this respect. SWR meter resolution, however, is very poor at low values of VSWR below, say, 1.5, where the meter is at 20 percent of full scale. Below 1.5 the meter scale is compressed so much that about the best you can do when adjusting the match is to tune for a null. Dynamic range of the SWR meter (without "expanded" scales) is thus not much greater than about 10 dB with good resolution.

Return loss measurements using the power meter, however, do not suffer from a lack of resolution, even at extremely low values of VSWR (<1.01) because of the increased dynamic range of the power meter, 80 dB. And to make a point, resolution is sufficient so that we could theoretically measure VSWRs of 1.0002 with the system described here if we were not limited by the directional bridge.

Admittedly, while there are few of us who really need to measure antenna VSWRs below, say, 1.5 or so, there are other reflection measurements which can't be made with most SWR meters because of their lack of sensitivity. Input VSWR of small-signal amplifiers, for example, will not admit the power levels necessary to make most SWR meters operate. Due to the increased sensitivity of the power meter, you can drive small-signal amplifiers with as little as −34 dBm and still measure a 1.2 VSWR (20 dB RL).

So while the SWR meter is an extremely useful device for continuous monitoring of VSWR under actual transmit conditions (something this system can't do), initial evaluation of antennas, amplifiers, and other devices can best be done with the power meter and bridge.

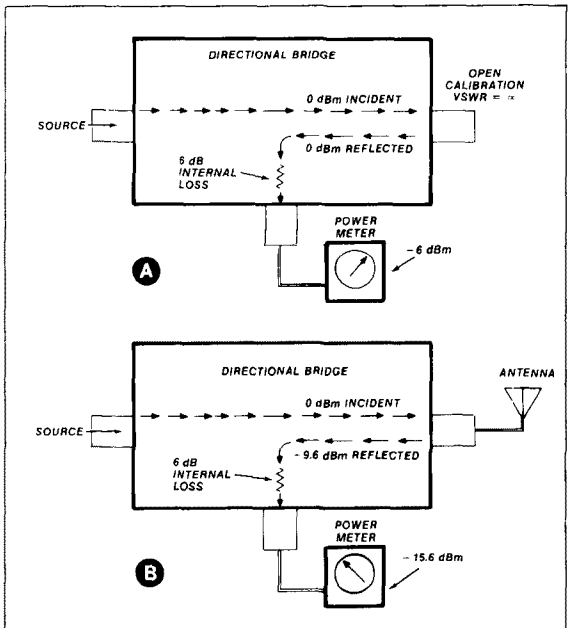


fig. 3. Setup for measuring antenna voltage standing-wave ratio. Reflection calibration is shown in (A); reflection measurement in (B).

how accurate is the measurement?

A detailed analysis of the accuracy of this measurement is not within the scope of this article. However, some general guidelines are given to make sure you make the best measurement possible.

There are two main sources of error in the return loss measurement described: source match and bridge directivity. These errors are limitations on all reflection measurements, whether with an SWR meter or the system described here; see fig. 4.

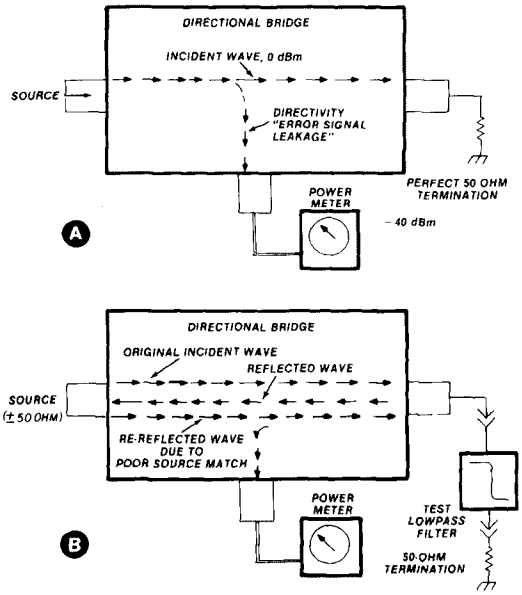


fig. 4. Reflection-measurement errors. The bridge directivity error is depicted in (A); (B) shows the source-match error.

Bridge directivity is a measure of how well the directional bridge separates the forward- and reverse-going waves. It is generally specified in dB. As an example, assume the directivity of the bridge is 40 dB. Practically speaking, this means that if our device under test (the antenna) were a perfect 50-ohm antenna with an infinite RL, we would still measure approximately 40 dB RL, even though there were no reflected waves traveling along the transmission line. Consequently the percentage errors in the measurement become increasingly large as the device RL approaches the bridge directivity. In this example any return loss measurements greater than approximately 35 dB would be unreliable. Fortunately, a 35-dB RL (VSWR 1.03) is usually well beyond the practical requirements of most measurements. The directivity of the bridge described here is greater than 40 dB up to 30 MHz.

The other source of error in reflection measurements is *source-match error*. Source match is essentially a measure of how close the output impedance of the source is to the characteristic impedance of the transmission line (50 ohms). Its importance becomes apparent when you consider the effect of any reflected energy traveling back to the source only to be reflected from the source, becoming part of the new forward-going wave. The forward-going wave now consists of two components (an infinite number if we count the re-reflections) to create an uncertainty in establishing the forward-going power in the calibration step. If the device we are measuring accepts most of the forward-going power (VSWR is low or RL is high), then this source of error becomes negligible.

If, on the other hand, the device has a reasonably high VSWR (a low RL), then source match error becomes appreciable. A source with a VSWR of 2.0, for example, used in the measurement of a device with an actual VSWR of 4.0 would yield a measured VSWR lying between 2.8 and 6.0. The value you would measure depends on the relative phasing of the component waves. When measuring the VSWR of reflective devices such as filters (outside of the passband), source match errors become significant. Ideally, then, the source used to make the measurement should have a 50-ohm (Z_0) output impedance to reduce source-match errors.

Fortunately, there are simple fixes to improve the source match of a given source. Simply adding a 6- or 10-dB attenuator at the output of the source brings the effective output impedance of the source/attenuator combination closer to 50 ohms. In the above example adding a 6-dB attenuator to the 2.0 VSWR source improves the effective source match to 1.4, reducing the uncertain window to 3.4-4.8 in a $VSWR = 4.0$ measurement.

The directional bridge has 6 dB of attenuation built in by design and satisfies this requirement on its own. However, when making transmission measurements remember to add 6 or 10 dB attenuation following the output of your source/filter, particularly when measuring large VSWRs (small RL). More about this later.

other notes on reflection measurements

As mentioned in part 1, the power meter is a broadband detector, one which responds equally well to the stimulus frequency, f_0, coming from the source or to any of the harmonics of the source or

the device being tested. Because of this, harmonic filtering of the source is a must, and suitable lowpass or highpass filters must be added to attenuate the source's harmonics adequately. Lowpass filters are recommended because of their relative ease of construction.

The skirt attenuation of the filters outside the passband should be sufficient to reject unwanted harmonic frequencies. The actual value of attenuation required will depend on the dynamic range required in the measurement, although 40 dB or greater harmonic rejection is usually enough, depending on the harmonic content of the source itself. In my system I use seven-pole LC lowpass filters with cutoffs at 5.8, 9.6, 15. 7, 23.1, and 30.4 MHz following my tunable generator to cover the high-frequency bands. These, combined with the inherent harmonic content of the oscillator itself, yield a source with a minimum −50 dBc harmonic content, sufficient for most of my measurements. LC lowpass filter construction is covered in detail in the *ARRL Handbook.*[1]

The attenuators shown surrounding the filters absorb the multiple reflections that result from out-of-band energy reflected from the filters and provide a proper termination for the filters and test amplifier. They should not be omitted from the circuit.

transmission measurements

The other type of measurement that can be made with the power meter is the transmission measurement. As the name implies, it is simply a measurement of the amount of signal power transmitted by a device under test. The measurement can be as simple as measuring the passband ripple and the stopband rejection of a filter, or as complex as meauring the gain, compression level, harmonics, intermodulation distortion (IMD) and third order intercept (TOI) of a small-signal amplifier.

A basic transmission measurement is shown in **fig. 2.** This setup would be suitable for characterizing a filter, for example, and the details of this measurement should be evident. The measurement of a small-signal amplifier's characteristics can be more involved and, therefore, will be discussed as an example of the measurement procedure. This measurement is shown in **fig. 5.** Note the liberal use of attenuators to buffer multiple reflections from the reactive filters, improve the effective source match, and provide a proper termination for the filters and test device.

calibration

Calibration consists of simply bypassing the test device (amplifier) with a through connection and noting the power level on the power meter. This should

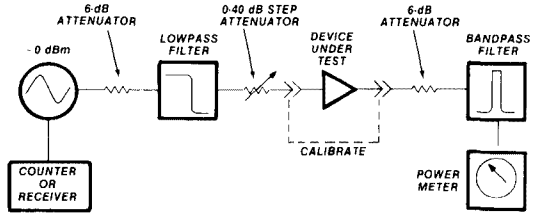


fig. 5. Instrumentation for small-signal amplifier gain, compression, and harmonic-distortion test.

be done with the 0-40-dB step attenuator adjusted to set the input power level low enough to prevent overdriving the amplifier.

measurement

Gain is measured by connecting the test amplifier and comparing the output power level with the calibration value (the input power level). In cases where the harmonics are known to be more than 10 dB below the fundamental level, the filter following the test amplifier can be omitted without serious errors in the gain measurement. If, for example, the harmonic power were 10 dB below the fundamental level, the error resulting from omission of the filter would be only 0.4 dB in the gain measurement.

The 1-dB gain compression level can be determined by increasing the drive to the test amplifier to a point where the gain, as measured in the preceding step, decreases by 1 dB. At this point the test amplifier is entering the nonlinear region and is generating enough distortion so that by choosing an appropriate bandpass filter we can measure the harmonic distortion. Back off on the drive a bit, however, since the measurement should be made with the amplifier operating in the linear mode and not near gain compression.

Measurement of *nth*-order harmonic distortion required choosing a bandpass filter that will attenuate the fundamental to a level at least 10 dB below that of the harmonic to be measured, as shown in **fig. 6.** We could not expect to be able to measure harmonic

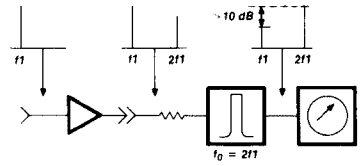


fig. 6. Attenuating the fundamental signal, f1, with a bandpass filter.

distortion 50 dB below the fundamental using a bandpass filter with only 30 dB of rejection of the fundamental, for example. Conventional Butterworth designs using from three to five poles as described in the *Handbook*[1] will provide sufficient attenuation in most cases.

Generally speaking, extreme bandpass-filter selectivity is not required, even in low-distortion measurements, for testing small-signal amplifiers since we can arbitrarily increase the distortion from the test amplifier by increasing the drive level to the input (but staying away from gain compression). **Fig. 7** illustrates this principle.

Note that in **fig. 7A** at an output level of −10 dBm, for example, the second harmonic is at −50 dBm, or relative to the fundamental at f1 we say that it is −40 dBc. If we increase the drive level to the test amplifier by 10 dB, the fundamental output also increases by 10 dB to 0 dBm as shown in **fig. 7B**.

But note that the second harmonic has increased by 20 dB and is now only −30 dBc relative to the fundamental. So given a three-pole bandpass filter with a 40-dB rejection over one octave of bandwidth, it would not be possible to make an accurate second-harmonic measurement with the drive level set as in **fig. 7A**; but by increasing the drive level as in **fig. 7B** we could make the measurement. Once the distortion has been measured at the artificially high drive level, the distortion at any nominal drive level can be computed from the equation:

$$HD_{,dBc}\ (nominal\ drive\ level) =$$
$$HD_{,dBc}\ (meas) + (N-1) \times (change\ in\ drive\ level) \quad \textbf{(3)}$$

where N is the order of distortion (that is, second, third, etc.). If, for example, the second harmonic were measured to be −40 dBc at a drive level of 0 dBm, it would compute to be −80 dBc at an input drive level of −40 dBm.

Again, stay away from gain-compression levels by at least a few dB, and remember that you can't measure test-amplifier distortion levels less than that generated by the source used and present at the input of the test amplifier. Also remember to take into account any insertion loss of the bandpass filter (it can be measured separately with the power meter) in your measurement of harmonic distortion.

The relationship between the fundamental and second-order harmonic distortion as the drive level is changed can be generalized to *nth*-order distortion as well: changing the drive level by 1 dB causes the *nth*-order distortion product to change by *nx1* dB. This fact is extremely useful in positive identification of the signal you think you are measuring. For example, when measuring the third harmonic, changing the drive by 1 dB should cause a 3-dB change in the power-meter reading.

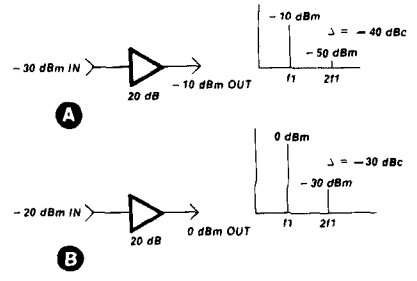


fig. 7. Effect of drive level on amplifier harmonic distortion at 2f1. (A) and (B) respectively show drive at −30 dBm and −20 dBm.

IMD and TOI measurements

IMD measurements follow the same general guidelines established in harmonic distortion measurements. One complication arises in the fact that we must now drive the test amplifier with two equal amplitude rf "tones" and somehow provide filtering to reject the fundamentals at f1 and f2 and pass the third-order distortion products at 2f1 ± f2 or 2f2 ± f1. **Fig. 8** shows the measurement setup.

Ideally we would like to present to the test amplifier two rf signals separated by, say, 10 or 20 kHz and measure the IMD product, which would be separated from the test signals by the same 10 or 20 kHz as

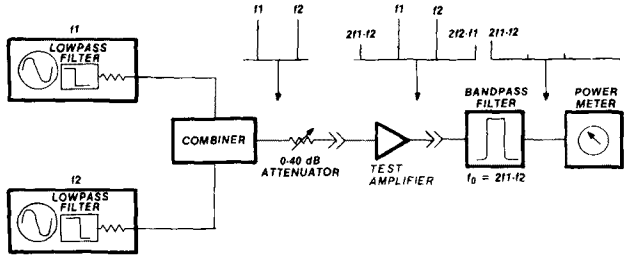


fig. 8. Test setup for measuring intermodulation distortion.

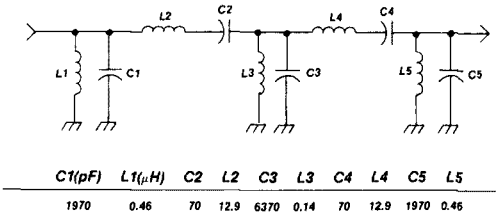


fig. 9. A 5.3-MHz Butterworth bandpass filter for testing intermodulation distortion. Filter-component values provide 50-dB attenuation at 7 MHz and above.

shown in **fig. 8**. This tone spacing is desirable since it simulates the situation that exists at the input to a receiver's preselected rf amplifier in crowded band conditions. However, without heterodyning the test amplifier's output to a lower frequency where filtering can be easily accomplished, it becomes necessary to separate the tones by at least a few MHz to allow using LC bandpass filters to select the IMD product and provide attenuation to the fundamentals at f1 and f2. Consequently, the measurement described here is limited to broadband amplifiers or amplifiers with a bandwidth large compared with the tone spacing. Fortunately, tests made with a spectrum analyzer using closely spaced tones show results that agree within a few dB compared with measurements made using tones spaced by a few MHz on broadband test amplifiers.

In my test setup I used two crystal oscillators at 7.0 MHz and 8.7 MHz and measured 2f1 – f2 at 5.3 MHz. **Fig. 9** shows filter component values for a 5.3-MHz bandpass filter that provides 50-dB attenuation at 7.0 MHz and above. As previously stated, the filters and test amplifier must see 50 ohms to provide a good termination. Also remember to verify the test by changing the drive level by a given amount, using the step attenuator, and look for a three times change in the power meter reading.

Once the third-order IMD is measured at the arbitrary drive level, the IMD at a nominal drive level can be computed from:

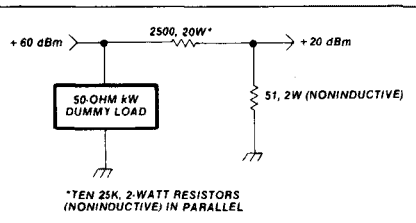


fig. 10. A 40-dB, 1-kW attenuator for making a-m measurements in a high-power transmitter.

$$IMD,_{dBc}\ (nominal\ drive\ level) =$$

$$IMD,_{dBc}\ (meas) + 2(change\ in\ drive\ level,\ dB) \quad (4)$$

and the *output* TOI can be computed from

$$TOI = \frac{\Delta}{2} + P_{out} \quad (5)$$

where Δ = *IMD* level in dBc relative to the fundamental (one tone), and P_{out} is the *output* level of *one* of the tones. Input TOI is the output TOI minus the gain of the test amplifier.

Measurement accuracy depends to a large extent on maintaining a 50-ohm impedance within the measurement instrumentation as well as the input and output impedance of the test amplifier itself. The measurement is meaningful only to the extent that the test device matches the impedance of the measurement instrumentation. Hence any networks used for input or output matching should be included as part of the measurement device.

One other comment: beware of IMD generated within the power combiner shown in **fig. 8**.[3] IMD caused by saturation of the toroids used in the combiner frustrated me for some time before I figured out what was going on. This combiner had 0.25-inch (6.35-mm) OD toroids that created their own IMD when driven above about + 10 dBm.

Although the foregoing tests were made on small-signal amplifiers such as those used ahead of a receiver, similar tests for harmonic distortion can be made on a high-power transmitter with the aid of an in-line power sampler such as is used in SWR meters. Examples of such samplers can be found in reference 1. Alternatively, a 40-dB pi attenuator capable of handling 1 kW can be made with the aid of a 1-kW dummy load and some 2-watt resistors. **Fig. 10** shows details. This attenuator will reduce the output of a kilowatt rig to a level that can be handled by the power meter.

measuring amplitude modulation

The power meter can also be used to measure amplitude modulation if the need arises and a scope isn't handy. The measurement is based on calculating the modulation percentage after measuring the power difference between the carrier with and without the modulation applied. A tone generator should be used to modulate the transmitter.

With modulation applied, the power meter (or the transmitter output) is adjusted to place the power meter reading near full scale, where scale resolution is best. Remove the modulation and measure the decrease in the power-meter reading. This difference, Δ, when plugged into the equation below, will

yield the modulation percentage to within a few percent, depending on how carefully you measure Δ.

$$modulation\ percentage = 170\sqrt{10^{(\Delta/10)}-1} \quad (6)$$

A difference of $\Delta = 1\ dB$, for example, would correspond to an 86.5-percent modulation level. This technique will provide good accuracy to about 30-percent modulation, where the power-meter scale resolution becomes marginal (0.2 dB). Results were verified using an HP-8640B calibrated signal generator. Remember to use an attenuator capable of dissipating the total power of the transmitter, or use a circuit similar to that in **fig. 10**.

extending operating frequency of the directional bridge

As mentioned earlier, the directional bridge has a directivity of about 40 dB to 30 MHz, dropping off to less than 10 dB or so at 150 MHz. By adding a 1-5 pF ceramic trimmer as shown in **fig. 11** and by *careful* parts placement, the balance can be improved to yield about 30-dB directivity at 150 MHz, permitting reflection measurements using the detector assembly (which is usable well beyond 150 MHz) and the modified bridge at 2 meters. The dynamic range of the detector assembly alone is about 20 dB (it departs from square-law operation above −10 dBm, and sensitivity is about −35 dBm), so the overall return-loss measurement range is about 20 dB, corresponding to a VSWR of 1.2. The VHF return loss adjustment procedure is shown in **fig. 11B**.

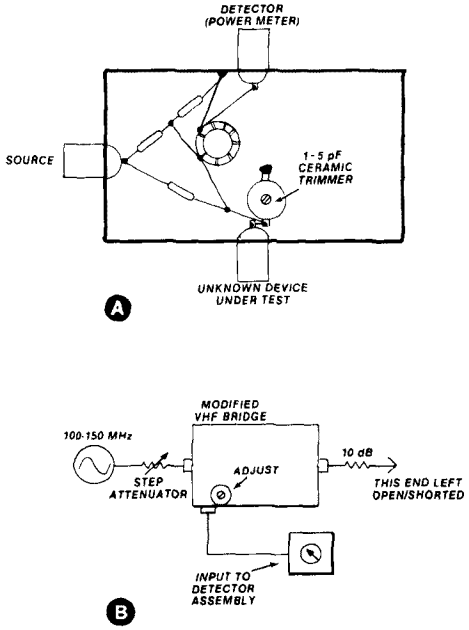


fig. 11. Making reflection measurements at VHF. A modified VHF directional bridge layout is shown in (A); (B) shows how to adjust the modified bridge for best directivity.

Initial adjustment of the modified return loss bridge is rather tedious. For best results it's necessary to adjust the trimmer and tweak the parts placement, particularly the toroid, while observing the return loss of a known device, a 10-dB attenuator connected to the unknown port of the bridge. With the 10-dB attenuator connected, the measured return loss (remember to calibrate with an open circuit first) should be 20 dB, since the signal must make two passes through the attenuator before reaching the bridge. There should be a range of adjustment over which you should measure this value.

A good indication that the bridge has been adjusted for directivity greater than 20 dB is to alternately short and open the open side of the 10-dB attenuator. If the directivity error signal has been nulled satisfactorily, the change in the power meter readings should be small (less than 1 dB). If not, readjust the trimmer capacitor and/or parts placement and try again. At some point the power meter variation as the attenuator is shorted/opened should be small. At this point try the same measurement at a lower frequency, say 50 MHz or 30 MHz, to see that you have not degraded the low-frequency directivity, since adding the capacitance disturbs the circuit balance somewhat.

Once you have adjusted the bridge to your satisfaction, epoxy the toroid in place using a *small* drop of epoxy (avoid coating the windings) to prevent it from moving. The assembly should then be sealed to prevent fingers from touching the insides.

closing remarks

Using this system I've been able to duplicate measurements on many of my homebrew projects that previously required the use of expensive laboratory measurement instrumentation. I can now measure the performance of projects and not wonder what effect a parts substitution had on a particular circuit, or whether adjustments were optimized.

Any questions or comments regarding construction of the power meter or the measurements described are welcome. Please include an SASE. Improvements doubtless can be made.

references

1. *The Radio Amateur's Handbook*, ARRL, Newington, Connecticut 06111, 1980 edition.
2. Wes Hayward, W7ZOI, and Doug DeMaw, W1FB, *Solid State Design for the Radio Amateur*, ARRL, Newington, Connecticut 06111.
3. William R. Hennigan, W3CZ, "Broadband Hybrid Splitters and Summers," *QST*, October, 1979, page 44.

ham radio

Questions and Answers

Entries must be by letter or post card *only. No telephone requests will be accepted. All entries will be acknowledged when received. Those judged to be most informative to the most Amateurs will be published. Questions must relate to Amateur Radio.*

Readers are invited to send a card with the question they feel is most useful that appears in each issue. Each month's winner will receive a prize. We will give a prize for the most popular question of the year. In the case of two or more questions on the same subject, the one arriving the earliest will be used.

Why is it that most Novices operate near the low end of the 21.0-21.2 MHz band? — Walter Legan, KA4KXX.

Perhaps they are trying to avoid interfering with the phone stations, or maybe they simply enjoy the company. The same thing happens on other bands, Novice or otherwise, CW or phone, but there doesn't seem to be good justification for it.

Next time the band is crowded, try calling CQ just below the upper end and see if you can reverse the trend. Certainly you will experience less QRM.

How do you prevent a lightning strike from entering your shack through your rotor wiring? — Ron Ankney, WD5IXP.

Lightning is unpredictable — it can enter your shack by various means, including of course, the rotator wiring. There is no accepted evidence that any form of protection can prevent a stroke (direct hit). It is wise, however, to provide some means of draining away static charges which can accumulate during summer storms and possibly become quite dangerous.

If you inspect the circuit diagram of your rotator, you will notice that the wiring is grounded at some point inside the mechanism. The TR-44, for example, employs a 500-ohm potentiometer inside the aluminum case; the arm of this pot is grounded to the frame. If the rotator is clamped to a grounded metal tower, static charges will drain off to the ground and will not enter the shack. To make sure of this, connect a piece of No. 12 or 14 drawn-copper, copper-clad, or No. 10 gauge aluminum "clothesline" to the rotator housing and run it in as straight a *line as* possible over the most direct route to a good ground.

If your antenna system is insulated from ground (mounted on top of a wooden tower or the roof), connect a No. 4 or larger wire to the rotator or frame of the system (at some point which will not interfere with operation of the antenna), and run it in a straight line down the tower to a good ground.

Article 810 of the National Electrical Code (NFPA No. 70), which is purely advisory but which is of interest here, recommends using an 8-foot-long galvanized iron pipe 3/4 inch in diameter as an effective ground. A 5/8-inch galvanized rod 8 feet long is also acceptable.

From a lightning protection standpoint, it is desirable to run coaxial cable and control wires directly down the tower and then underground to the shack. It is also a good idea to ground the braid of the coax to a water pipe system at the point of entry into the shack, if possible, using a 1/2-inch or larger copper strap soldered to the braid and clamped to the pipe. If a water pipe system is not available, drive a ground stake into the ground immediately outside the house, at the point of entry, and ground the coax braid to it.

Glass or silk, when rubbed, produce static electricity. Why aren't they good conductors? — Lawrence Emmett.

It is convenient to define two kinds of electricity, positive and negative. The elementary electric charge is the negative electron. To charge a body negatively you add electrons to it; the only way to charge it positively is to take some electrons away from it. Think of the atom as a neutral body under normal conditions. Remove some electrons and it becomes a positively charged ion. Add some electrons and it becomes a negatively charged ion.

In some substances the forces holding the electrons to the atoms are small, and some electrons may become detached temporarily from the atom and wander in the vacant space between the atoms. This is particularly true of the metals, such as silver and copper.

If the electrons are more rigidly bound to the atom, so that they cannot be freed except under the action of very large forces, no free electrons will be found in the empty spaces between atoms. If an electric force is applied to such a substance, it cannot cause the electrons to migrate and there's no flow of electrons (no current flow) from one part of the substance to the other. If an excess number of electrons are placed on one part of such a substance, they remain there. Glass, mica, quartz, wood, and ebonite are examples of such substances, which we know as insulators.

When a glass rod is rubbed with a silk cloth, some electrons pass from the rod to the silk, leaving the rod charged positively and the silk negatively. However, since electrons cannot migrate in these insulators, current won't flow in them.

What do I do in case of an emergency involving the sending or receiving of an SOS? — Steve Reisman, KA6IVE.

If you suddenly find yourself in an emergency, you can call SOS on CW or MAYDAY on phone. Chances are you will receive one or more immediate replies on your frequency requesting your location and details of the emergency. Respond to the strongest signal. Generally, an emergency net will be quickly set up and a net-control station will be selected who will act as the supreme authority in the situation. Listen to him carefully, answer his questions briefly, and do exactly what he tells you to do.

Emergency nets are not pre-arranged — they happen. The reason for this is that many Amateur operators know exactly what to do in an emergency without much thought. They have operated nets before and know how to pass the maximum amount of information with the minimum number of words in a minimum of time. If you aren't familiar with net procedures, listen to them and try getting involved. It may help you or somebody else when a real emergency arises.

On the other hand, if you should hear a distress call, listen for a few seconds to see if somebody else responds. If so, listen carefully but stay off the air unless it becomes clear that there is a specific job to be done that you can handle more efficiently than anyone else.

If nobody else responds, you certainly must do so. Stay calm. Ask the distressed station to provide you with details. Remember that other stations may now be tuned in and assessing the situation, and they may join you. In any event, don't rag-chew.

If it appears that you personally can't be of much help, you can call QST to attract other stations who might be better able to help, and you can call your ARRL Area Emergency Coordinator on the telephone and ask his help. (If you don't know his telephone number, look it up and post it in your shack. Do it now!) Be prepared. You might also want to monitor W1AW transmissions for latest emergency information if you are not directly involved in the emergency.

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computer program for sorting and inventory of standard resistor values

A useful tool for experimenters with overflowing junkboxes

A friend of mine is in the surplus electronics business. He buys closeouts and overstocks then sorts what he has bought and resells them. Recently he made a large buy on surplus resistors. Most were in plastic bags, but some had been attacked by rats. Thus sorting and inventory wasn't going to be easy. He asked me if my computer could make a list for performing the inventory. **Table 1** is the result of that request. An abbreviated example of the program output is also given.

The idea of using a computer program to generate this list is made practical by the fact that resistor values follow a distinct pattern. There are only 24 possible combinations for the first two digits of a resistor value. These digits are then multiplied by a power of 10 to form all the values. The lowest value is 1.0 ohm and the highest is 2.2×10^7 ohms, or 22 megohms. (This same pattern is followed by capacitor values.)

The program was written in TSC extended BASIC and runs on a Southwest Technical Products (SWTP) computer system.* Lines 50 through 80 establish the standard value table using the DATA statement. The FOR loops at 210, 260, 290, 370, 440, and 490 generate the values by multiplying the table values by various powers of ten.

The entire list could have been generated by a set of nested loops except for formatting the value column. The subroutine at line 600 handles printing the spaces where the values are to be manually entered and also handles page headings. The columns are set up for 1/4-, 1/2-, 1-, and 2-watt resistors. To change this it's only necessary to change lines 610 and 710.

*TRS-80 level-2 BASIC and APPLESOFT BASIC for the APPLE II can be run with no program changes.

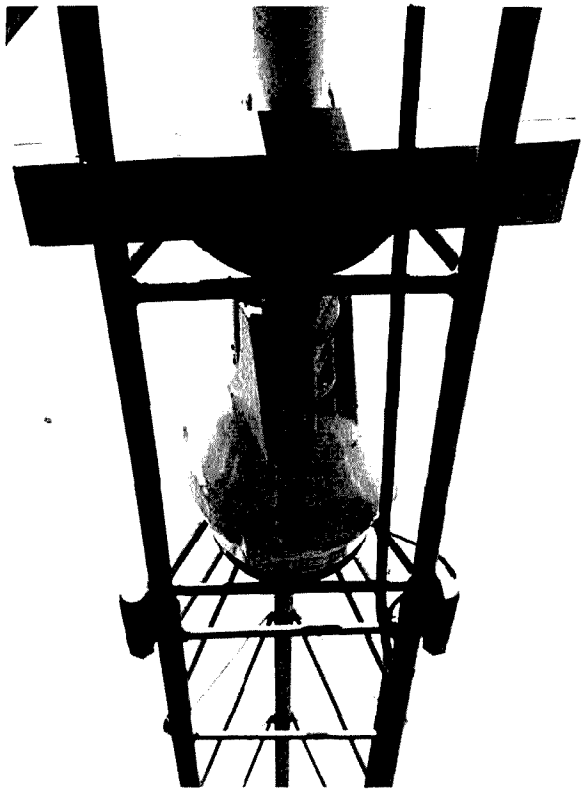
By Phil Hughes, WA6SWR, Specialized Systems Consultants, P.O. Box 2847, Olympia, Washington 98507

```
 10 REM RESISTOR  4-15-80
 20 REM Specialized Systems Consultants
 30 REM Olympia, WA
 40 REM STANDARD VALUES
 50 DATA 1,1.1,1.2,1.3,1.5,1.6,1.8
 60 DATA 2,2.2,2.4,2.7,3,3.3,3.6,3.9
 70 DATA 4.3,4.7,5.1,5.6,6.2,6.8,7.5
 80 DATA 8.2,9.1
 90 REM
100 PRINT "RESISTOR INVENTORY LIST"
110 INPUT "ENTER TOLERANCE (5 OR 10)",P
120 IF (P<>5) AND (P<>10) THEN 110
130 PRINT "POSITION PAPER TO TOP OF PAGE AND HIT RETURN"
140 A$=INCH$(0)
150 IF A$<>CHR$(13) THEN 140
160 IF P=10 THEN R=12 ELSE R=24
170 IF P=10 THEN R1=5 ELSE R1=9
180 PRINT
190 GOSUB 670
200 REM 1 TO 9.1 OHM
210 FOR J=1 TO R
220 GOSUB 740
230 PRINT USING "#####.#",V;
240 GOSUB 600
250 NEXT J
260 FOR I=1 TO 4
270 REM 10 TO V1000 OHM
280 RESTORE 50
290 FOR J=1 TO R
300 GOSUB 740
310 PRINT USING "###,###",V*10^I;
320 GOSUB 600
330 NEXT J
340 NEXT I
350 REM .1 MEG TO .91 MEG
360 RESTORE 50
370 FOR J=1 TO R
380 GOSUB 740
390 PRINT USING ".##\12\",V/10," Meg";
400 GOSUB 600
410 NEXT J
420 REM 1 MEG TO 9.1 MEG
430 RESTORE 50
440 FOR J=1 TO R
450 GOSUB 740
460 PRINT USING "#.#\12\",V," Meg";
470 GOSUB 600
480 NEXT J
490 REM 10 MEG TO 22 MEG
500 RESTORE 50
510 FOR J=1 TO R1
520 GOSUB 740
530 PRINT USING " ##\12\",V*10," Meg";
540 GOSUB 600
550 NEXT J
560 FOR I=1 TO 67-LC
570 PRINT
580 NEXT I
590 END
600 REM PRINT END OF LINE
610 PRINT "      ________      ________      ________      ________"
620 LC=LC+1
630 IF LC<60 THEN RETURN
640 FOR K=1 TO 6
650 PRINT
660 NEXT K
670 REM PAGE HEADING AND SET LINE COUNT
680 LC=4
690 PRINT "     RESISTOR INVENTORY LIST FOR  _____ ____, 19____"
700 PRINT
710 PRINT "  VALUE     1/4W       1/2W          1W          2W"
720 PRINT
730 RETURN
740 REM READ NEXT VALUE
750 IF P=5 THEN READ V
760 IF P=10 THEN READ V,W
770 RETURN
```

table 1. (left) Program listing for sorting and inventory of resistors. Below is an abbreviated example of program output.

```
 VALUE     1/4W       1/2W          1W          2W

   1.0     ________   ________      ________    ________
   1.2     ________   ________      ________    ________
   1.5     ________   ________      ________    ________
   1.8     ________   ________      ________    ________
   2.2     ________   ________      ________    ________
   2.7     ________   ________      ________    ________
   3.3     ________   ________      ________    ________
   3.9     ________   ________      ________    ________
   4.7     ________   ________      ________    ________
   5.6     ________   ________      ________    ________
   6.8     ________   ________      ________    ________
   8.2     ________   ________      ________    ________
    10     ________   ________      ________    ________
    12     ________   ________      ________    ________
    15     ________   ________      ________    ________
    18     ________   ________      ________    ________
    22     ________   ________      ________    ________
    27     ________   ________      ________    ________
    33     ________   ________      ________    ________
    39     ________   ________      ________    ________
    47     ________   ________      ________    ________
    56     ________   ________      ________    ________
    68     ________   ________      ________    ________
    82     ________   ________      ________    ________
   100     ________   ________      ________    ________
   120     ________   ________      ________    ________
   150     ________   ________      ________    ________
   180     ________   ________      ________    ________
   220     ________   ________      ________    ________
   270     ________   ________      ________    ________
   330     ________   ________      ________    ________
   390     ________   ________      ________    ________
   470     ________   ________      ________    ________
   560     ________   ________      ________    ________
   680     ________   ________      ________    ________
   820     ________   ________      ________    ________
 1,000     ________   ________      ________    ________
 1,200     ________   ________      ________    ________
 1,500     ________   ________      ________    ________
 1,800     ________   ________      ________    ________
 2,200     ________   ________      ________    ________
 2,700     ________   ________      ________    ________
 3,300     ________   ________      ________    ________
 3,900     ________   ________      ________    ________
 4,700     ________   ________      ________    ________
 5,600     ________   ________      ________    ________
 6,800     ________   ________      ________    ________
 8,200     ________   ________      ________    ________
10,000     ________   ________      ________    ________
12,000     ________   ________      ________    ________
15,000     ________   ________      ________    ________
18,000     ________   ________      ________    ________
22,000     ________   ________      ________    ________
27,000     ________   ________      ________    ________
33,000     ________   ________      ________    ________
39,000     ________   ________      ________    ________
```



Mast lock installed on author's tower.

beam antenna mast lock

Simple clamp device for preventing windmilling

There are frequent occasions when it's necessary to secure a beam antenna in a fixed position to prevent it from spinning or windmilling, or from changing its vertical position relative to the rotator when the rotator has been removed for maintenance, routine or otherwise. The antenna clamp described here meets that requirement completely. It is not only effective and easy to make, but it even costs less than two dollars for materials. Before going further, I want to explain that the term *mast* is used to denote the pipe to which the antenna is mounted and which is turned by the rotator. It does not refer to the tower structure.

clamp description

Briefly, the clamp consists of a piece of oak or other hardwood 2 × 4 × 13 inches (50.8 × 102 × 330 mm) and a pair of 2 1/2 × 5/16 inch (64 × 8 mm) U bolts. See **fig. 1**. (The lumber dimensions are those that best fitted my EZ-WAY tower installation.) For other towers it may be necessary to change the longer dimensions, making it about 4 inches (102 mm) more than the distance between the legs at the height of the rotator.

The device is clamped to the mast by means of the U bolts (**fig. 2**). The 2-by-4 lumber piece should rest on the cross member, which is just above the rotator. It's important that the small backing plates that accompany the U bolts are used so that maximum pressure may be exerted on the wooden member to prevent any slippage between the bolts and the mast. Merely putting washers beneath the nuts *will not* accomplish this. Remember that we're dealing with considerable twisting force on the clamp.

The clamp not only prevents the antenna from turning but *also* maintains the vertical position relative to the rotator. This can be very critical when the rotator is reinstalled. It may be necessary

By Lefferts A. McClelland, W4KV, 109 Anona Place, Indian Harbour Beach, Florida 32937

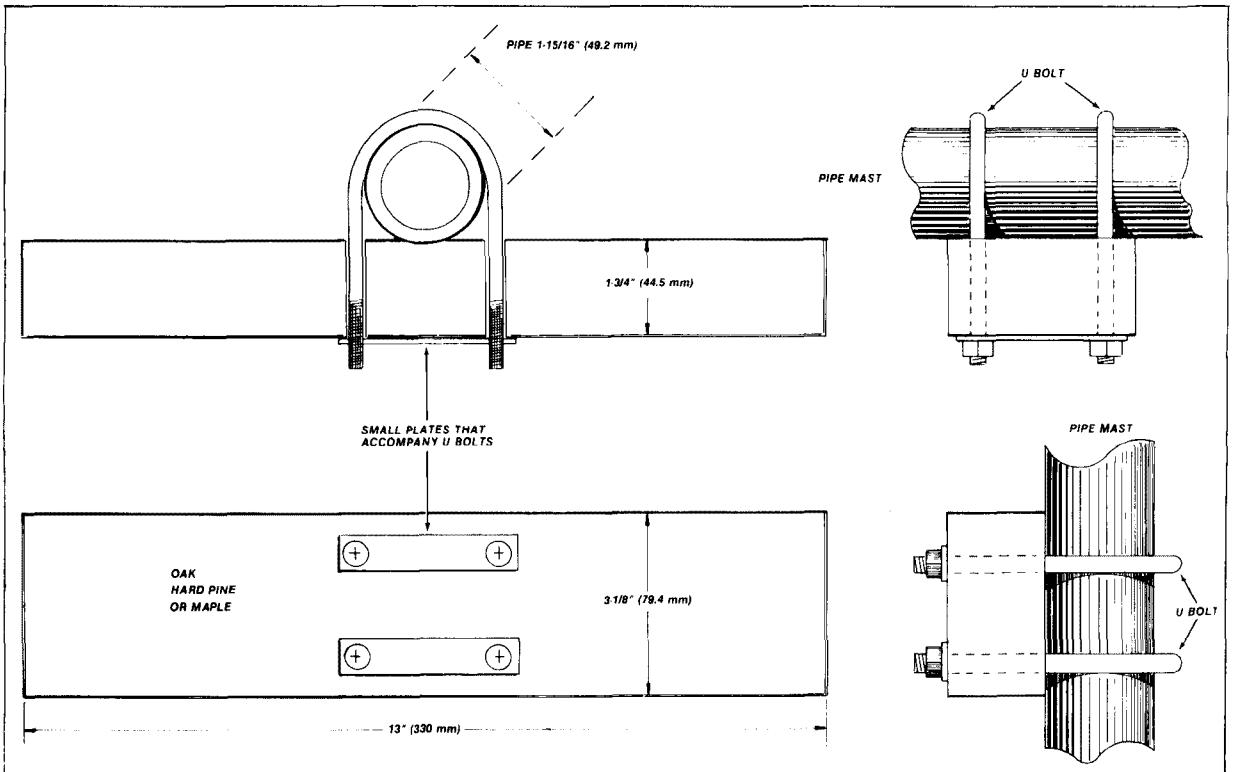


fig. 1. Assembly drawing of the beam antenna mast lock. These dimensions are measured from the clamp. Sizes given in the text are nominal; 2 × 4 lumber varies from 1-1/2 × 3-1/4 to 2 × 4 for unplaned mill material.

to add shims or small wedges between the clamp and the tower legs to obtain a tight lock-up.

With my EZ-WAY foldover tower, I position the beam antenna so that, when lowered, either the reflector or the director lies flat on the ground. This action relieves the strain on the antenna elements when the antenna is down and puts the antenna in a fixed position of reference. In this position, the base casting and rotatable upper casting should be indexed by means of a China marking pencil or a strip of paint. The dial of the control box should be marked to indicate the azimuth of the system before it was lowered. With everything thus marked no further alignment should be necessary after reinstallation of the serviced rotator.

Whenever I leave town for any length of time, I install the clamp to relieve the rotator of torque caused by heavy on-shore winds (my property is very close to the Atlantic Ocean.)

This has been a practical solution to a bothersome problem.

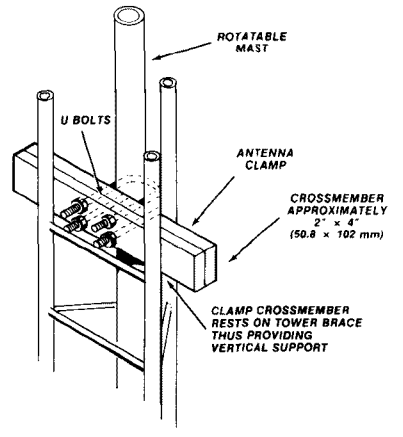
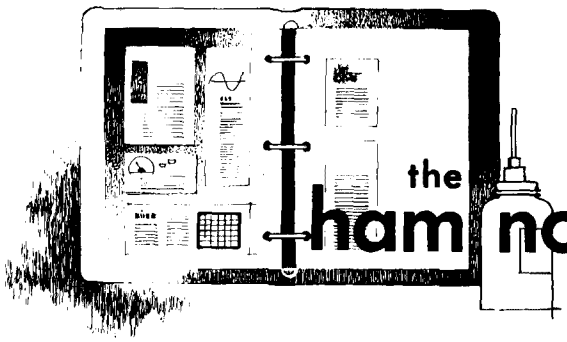


fig. 2. Isometric view of the mast lock.

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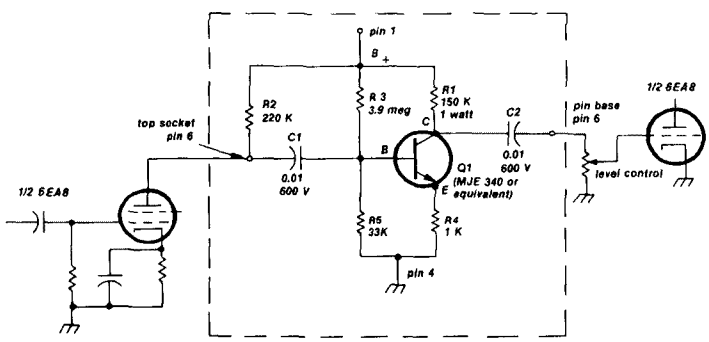
the ham notebook

simple speech amplifier for the SB-400/SB-401

This speech amplifier has no plugs, cables, or interconnections. It turns on and off automatically with the transmitter switch. It's a plug-in module that receives its power from the transmitter, and it doesn't disturb the original design of the SB-400 or SB-401. The amplifier can be plugged in or removed in a few seconds.

The plug-in module was designed to give additional drive power to the triode section of the ring modulator in the SB-400/SB-401. It is inserted between the pentode and triode sections of the 6EA8 tube in the SB-400/SB-401. In these rigs, all audio work is accomplished by the 6EA8. The pentode section of the 6EA8 drives the triode ring-modulator section. It's between these two 6EA8 sections that additional gain is needed to give additional speech amplification.

The plug-in module is simple. It consists of five resistors, two capacitors, a transistor, and a nine-pin test socket with a small circuit board. **Fig. 1** shows the schematic; **fig. 2** gives construction details.



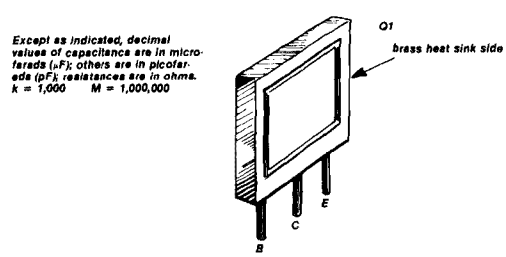


fig. 1. Schematic diagram, plug-in amplifier for Heath SB-400/SB-401 transmitter.

construction

Disassemble the nine-pin test socket by removing the No. 6 terminal pin. Drill a small hole through the side of the test socket one-half inch (12.7 mm) from the pin base at a slight angle. Reinsert the pin through this hole to provide an output and input circuit for the amplifier connection (see **fig. 2**).

Mount the parts on a small circuit board (fiber board is okay). Drill a 3/4-inch (19-mm) hole at one end to accept the nine-pin test socket. Cut a small angle on the board at the right-hand corner for clearance of the capacitor when inserting the module into the 6EA8 socket.

Insert the test socket into the board and cement it with epoxy. Reinsert the pin through the side of the test socket, adjusting the board so that it's parallel with the transformer.

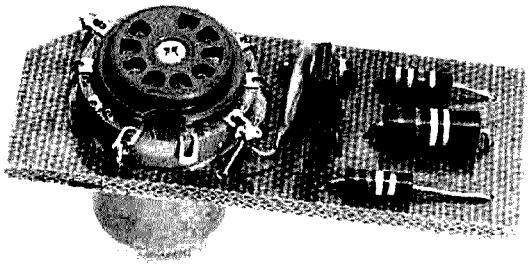
parts

Here's a list of components you'll need:

C1,C2 0.01 μF 600V
Q1 MJE340 (Motorola or equivalent)
nine-pin test socket
R1 150k 1 watt
R2 220k 1/2 watt
R3 3.9 meg 1/2 watt
R4 1k 1/2 watt
R5 33k 1/2 watt

installation

Simply remove the 6EA8 from the transmitter and insert the 6EA8 into



Completed amplifier module for the SB-400/401 transceiver.

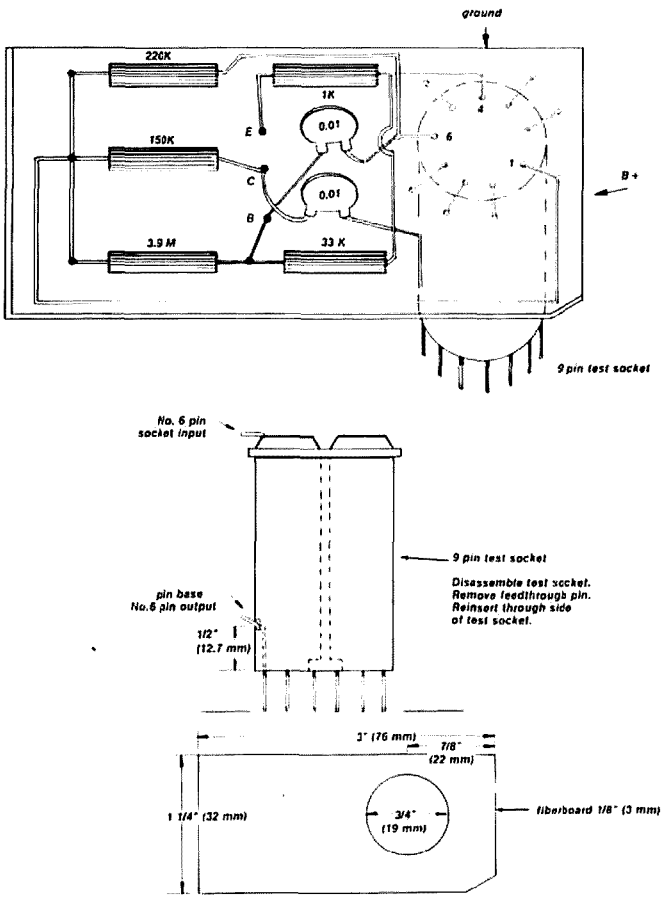


fig. 2. Construction details for the plug-in amplifier module used in the Heath SB-400/SB-401 transmitters.

the amplifier socket. Then insert the amplifier module into the 6EA8 socket. Set the audio level control at 9 o'clock. That's all there is to it. You don't have to use external amplifiers to obtain additional gain. As a matter of fact, such amplifiers, when inserted into the transmitter microphone jack, will overdrive the 6EA8.

Steve Hresko, W8MLH

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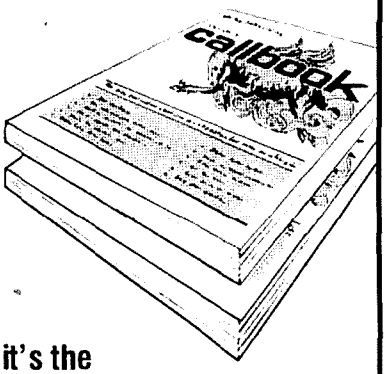
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Coming Events
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ILLINOIS: Radio Expo '81 sponsored by the Chicago FM Club will be held, rain or shine, on September 19th and 20th at the Lake County Fair Grounds, routes 45 and 120 in Grayslake. Grayslake is 30 minutes north of Chicago and 45 minutes south of Milwaukee. This year we will have a super large flea market with plenty of indoor and outdoor space, free with a gate ticket. Just bring your own table and chair or tailgate it. Parking is free. We will also have new camping sites complete with power hook-ups. There will be Ham seminars both Saturday and Sunday. YL's have a ladies program and door prizes both days. Only the best manufacturers of Ham and computer equipment and their distributors will be at our huge display building for you to meet and buy from. As in the past, Expo will be giving out thousands of dollars worth of prizes and admission tickets are good for both days. For advanced registration, send $3.00 per person and a #10 S.A.S.E. to Radio Expo Tickets, P.O. Box 1532, Evanston, Illinois. Tickets at the gate are $4.00 each. Kids under seven are free. For more information call (312) BST-EXPO. Talk-in on 146.16/.76, 146.52, and 222.5/224.10.

ILLINOIS: The JAARC will hold its 16th annual hamfest and flea market on June 21 at the Morgan County Fairgrounds in Jacksonville. Limited free indoor space and large outdoor flea market area. Free coffee and doughnuts from 8 to 9 AM. Food on the grounds. Talk-in on 146.52. Tickets $2.00 or 3/$5.00. See WB9RAL or WD9EBK for more info.

SOUTHERN ILLINOIS: Shawnee Amateur Radio Association's 25th anniversity Silver Jubilee Hamfest will be August 30 at JOHN A. LOGAN College in Cartersville, Illinois. Offerings include Air Conditioned Flea Market — Prizes — Forums — Computers — Food — Refreshments — Contests. For details QSL Bill May, KB9QY, 800 Hilldale, Herrin, IL 62948 or (618) 942-2511 days.

INDIANA: The Lake County A.R.C.'s ninth annual Hamfest on June 21st at the Lake County Fairgrounds in Crown Point. All tickets: $2.00. Talk-in on club repeater 147.84/.24 and 146.52. More info or tickets: S.A.S.E. "Mike" Evanson, KA9COM, 8037 Monaldi Dr., Munster, Indiana 46321.

MARYLAND: The Baltimore Radio Amateur Television Society announces its annual Maryland Hamfest on July 26th at the Howard County Fairgrounds, Route 32, adjacent to Interstate 70, 15 miles west of Baltimore. Tickets: $3.00 (XYL's and children under 12 free), tailgating spaces $2.00, tables $5.00 each. More information: BRATS, Box 5915, Baltimore, MD 21208 or call Mayer, W3GXK (301) 655-7812.

MICHIGAN: The Straits Area Amateur Radio Club's annual hamfest on July 18th at the Harbor Springs High School in Harbor Springs. Doors open for sellers at 8:00 and for the rest at 9:00. Donation: $2.00. Prizes, lunch, overnight parking, shopping nearby for YL's, and much more. Talk-in on .52 simplex and 146.07/.67. More info: Mr. Bernie Stotnick, KB8RE, 630 Ann St., Harbor Springs, MI 49740. (616) 526-5614.

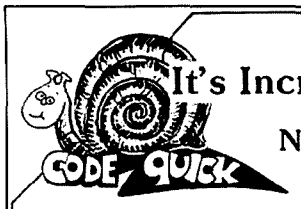
MONTANA: The Great Falls Area A.R.C.'s Glacier-Waterton International Hamfest on July 17th-19th at the Three Forks Campground located between East and West Glacier on Highway 2. Hams from Canada and the Northwestern U.S. will participate in forums, technical presentations, exhibits and demonstrations. Ladies and children will have their own activities including horseback riding. Preregistration: $6.00, after July 7th: $7.00. Campsites with and without hookups available. More info: Glacier-Waterton Hamfest, Shirley Smith, Secretary, 1822 14th Ave. South, Great Falls, Montana 59405. (406) 452-1886.

NEW YORK: The Genesee Radio Amateurs', ARRL approved Batavia Hamfest on July 12th at the Alexander Firemen's Grounds, Route 98, in Alexander. Doors open at 7:00 AM. Advanced admission: $2.00 and $3.00 at the gate. Flea market is $1.00. Prizes, large exhibit area, programs, YL activities, contests, plenty of food, overnight camping, boat anchor auction and much more. Talk-in to W2RCX on 146.04/.64, 144.71/5.31 and .52 simplex. More info and advanced tickets: S.A.S.E. to GRAM, Inc., Box 572, Batavia, NY 14020.

NEW YORK: The Rome Radio Club's 29th annual "Ham Family Days" on June 7th at Beck's Grove, 10 miles west of Rome just off of Route 49. Starts at 9:00. Flea market, displays, and more. Talk-in on 146.28/.88, 146.34/.94 and .52 simplex.



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NEW YORK: The Staten Island Amateur Radio Association's flea market on June 13th on the grounds of the All Saints Episcopal Church, Victory Blvd. and Wooley Ave. starting at 9:00 AM. Take interstate 278 to Victory Blvd. exit, then ½ mile east on Victory Blvd. No admission charge for buyers. Sellers: $3.00 and own tables. Talk-in on 146.28/.88 and 146.52. More info: S.A.S.E. to WA2AMJ, P.O. Box 495, Staten Island, NY 10314.

NORTH CAROLINA: The Cary Amateur Radio Club's ninth annual Mid-summer Swapfest on July 18th at the Lions Club Shelter in Cary (near Cary High School). Starts at 9:00 AM. Buying, selling, auction, prizes, and much more. Registration for prizes: $3.00 (top prize is a TS-520 SE). No admission charge. Talk-in on 146.28/.88, 147.75/.15, and 146.52. More info: Cary ARC, P.O. Box 53, Cary, NC 27511.

OHIO: The Tusco A.R.C. and Canton A.R.C.'s seventh annual Hall of Fame Hamfest on July 19th at the Nimishillen Grange, 6461 Easton St., Louisville. Giant flea market, dealers, food, XYL activities, CW contest, super awards, and more. $2.50 advanced and $3.00 at the gate. Tables must be reserved. For reservations, tickets, or more info: WA8SHP, 10877 Hazelview Ave., Alliance, Ohio 44601.

OHIO: The Champaign — Logan A.R.C.'s annual hamfest on June 14th at the Logan County Fairgrounds, S. Main St. and Lake Ave., Bellefontaine. Prizes, free parking, and much more. Admission: $1.50 advanced and $2.00 at the door. Trunk and table sales: $3.00. Bid table available this year. Talk-in on 146.52 simplex and Hi-Point repeater. More info: W8HFK, John L. Wentz, Box 102, West Liberty, OH 43357 or WD8NEB, Paul F. Merine, Box 185, West Mansfield, OH 43358.

OHIO: The 17th annual Wood County Ham-A-Rama on July 19th at the Bowling Green Fairgrounds in Bowling Green. Opens at 10:00 AM. Free admission and parking. Trunk sale space and food available. Prizes. K8TIH talk-in on .52. Tickets are $1.50 in advance and $2.00 at the door. Write to: Eric Willman, 14118 Bishop Rd., Bowling Green, OH 43402. Advance table rental to dealers only: $3.00 per table, payable in advance. Saturday set-up available. Send check for tables to: Bill Wilkins, 16220 Portage Rd., Bowling Green, OH 43402.

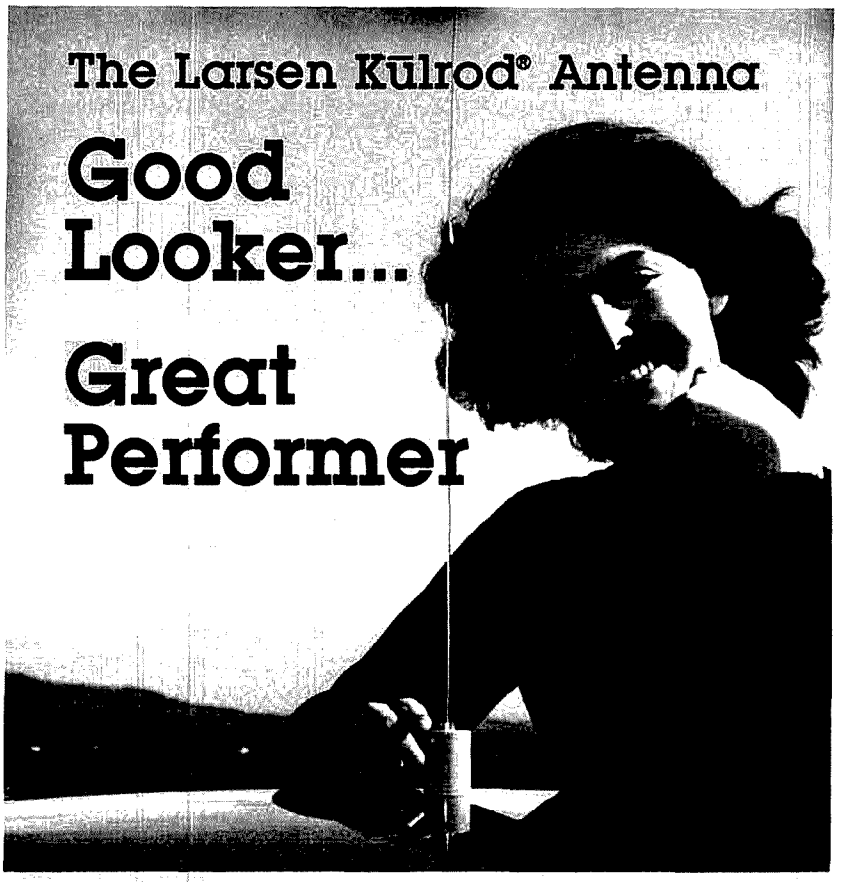
OHIO: The Northern Ohio Amateur Radio Society's "Noarsfest" on July 25th at the Lorain County Fairgrounds in Wellington. Over 100 prizes, flea market, parking available, large indoor exhibit hall, refreshments, overnight camping (no hookups), plus much more. Donations: $2.50 advanced and $3.00 at the gate. Dealer tables: $5.00 each. Talk-in on 146.10/.70 or .52 simplex. Tickets or info: S.A.S.E. to Noarsfest, P.O. Box 354, Lorain, Ohio 44052. Dealers: George Morningstar, W8ANM, 198 Glenview Dr., Avon Lake, Ohio 44012. (216) 933-2841.

OHIO: The Lancaster and Fairfield County A.R.C.'s annual family hamfest on June 21st at The P & R Party Barn, 4 miles west of Lancaster off of Rt. 188. Overnight camping and many, many activities for the family. Starts at 9:00 AM. Advanced tickets are $2.00 and at the door $3.00. Flea market tables are $2.00 and trunk sales are $1.00. Talk-in on 147.63/.03 or .52 simplex. More info: C. Ted Riley, WB8VOA, P.O. Box 3, Lancaster, Ohio 43130 or call (614) 653-8222.

OKLAHOMA: The West Gulf Division ARRL Convention and famed "Ham Holiday" will be held on July 24th - 26th at Oklahoma City's Myriad Convention Center in downtown Oklahoma City. Sponsored by the Central Oklahoma Radio Amateurs, the program will include forums, technical talks, a OCWA breakfast, a full ladies program, many prizes, plus much more. Pre-register by July 7th for $6.00 or pay $7.00 after the 7th. Immense ground-level indoor exhibitor and swapfest are available. Tables free to non-commercial registrants. More info or tickets: CORA, P.O. Box 20118, Oklahoma City, OK 73120.

PENNSYLVANIA: Harrisburg RAC Annual Firecracker Hamfest on Saturday, July 4th at the Shellsville VFW picnic grounds. Exit #27 off I-81, north one mile from exit. Parking for 1000 cars. Shade trees with pavillion. Food available. Talk-in on .52 and .16/.76. Admission is $3.00, tailgating is $1.50. XYL and children free.

PENNSYLVANIA: The Nittany A.R.C.'s annual Mount Nittany Hamfestival on July 11th at the HRB-Singer, Inc. picnic grounds in State College. Flea market, auction, dealers, door prizes and free parking. Refreshments and food available. Also the famous Central Pennsylvania Festival of the Arts on the Penn State University campus. Advanced registration is $2.00 and at the gate is $3.00. XYLs and children free. Flea market space is $3.00 in advance and $5.00 on site. Talk-in from I-80 and other central Pennsylvania routes on .16/.76 and .25/.85, local direction on .52 simplex. More info: Mount Nittany Hamfestival, NARC, Box 614, State College, PA 16801 or call Dave Buckwalter, N3BBH at (814) 234-0759.



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HAM CALENDAR

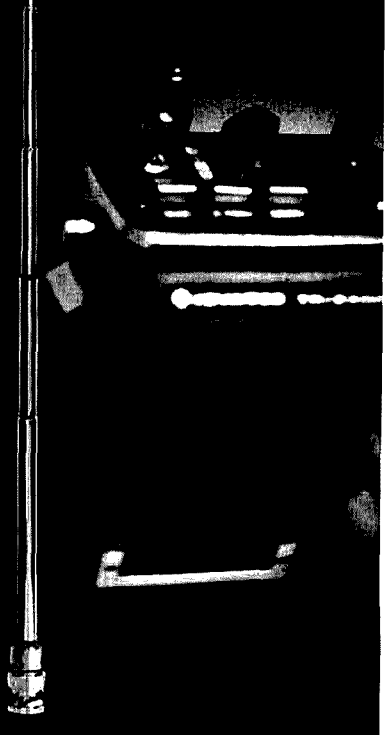
June

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	WEST COAST BULLETIN — 8 PM PST (0400 UTC) 3540 KCS, A-1 22 WPM **1.** **1**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **2**	**3**	**4**	**5**	**INDEPENDENT REPEATER ASSOC. — GRAND RAPIDS SPRING SWAP & SHOP** — National Guard Armory, 44th St., Grand Rapids, MI — WD8NZZ **6.** **6**
OLE VIRGINIA HAMS, A.R.C. Inc. — MANASSAS HAMFEST — Prince William County Fairgrounds, Rt. 3, 234 Manassas, VA 22110 **7.** **CHELSEA SWAP & SHOP** — Chelsea Fairgrounds, Chelsea, MI — Wm. Altenberndt, 3132 Timberline, Jackson, MI 49201 **7.** **ROME RADIO CLUB HAM FAMILY DAYS** — Beck's Grove (10 mi. west of Rome off Rt. 49 at Beck's Grove Airport) Rome, NY 13440 — KA2DAI **7.** **7**	**DELTA DIVISION DENATOBIA, MS** — W5GAM **7-8.** **8**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **9**	**10**	**11**	**ARRL CONVENTION** Ohio State, Cincinnati **12-13.** **12**	**STATEN ISLAND AMATEUR RADIO ASSOC. FLEA MARKET** — St. Episcopal Church, Victory Blvd. & Wooley Ave., Staten Island, NY 10314 — WA2AMJ **13.** **ARRL VHF QSO PARTY 13-14.** **13**
CLINTON & HIGHLAND COUNTY RADIO CLUB ANNUAL HAMFEST & FLEA MARKET — Clinton County Fairgrounds, S.R. 22, Wilmington, OH **14.** **CHAMPAIGN/LOGAN ARC ANNUAL HAMFEST** — Logan County Fairgrounds, S. Main St. & Lake Ave., Bellefontaine, OH 43311 — WD8NEB **14.** **SIX METER CLUB OF CHICAGO 24th ANNUAL HAMFEST** — Santa Fe Park, 91st & Wolf Rd., Willow Springs, IL — WB9SPV **14.** **MILTON ARC 10th ANNUAL MARCH HAMFEST** — Allenwood Fireman's Fairgrounds, U.S. Rt. 15, Milton, PA 17847 — Harold Dennin, POB 235, Milton, PA 17847 **14.** **SATELLITE ARC ANNUAL SANTA MARIA SWAPFEST** — POB 1615, Vandenberg, AFB, CA 93437 **14.** — *JUNE 14 CONT. BOTTOM RIGHT* **14**	**WEST COAST BULLETIN** — 8 PM PST (0400 UTC), 3540 KCS, A-1, 22 WPM **15.** **15**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **16**	**17**	**18**	**SIX-METER INTERNATIONAL RADIO CLUB 7th ANNUAL SUMMER SMIRK PARTY CONTEST** — 1900 hrs. CDT Friday 19 June to 1900 hrs. Sunday 21 June — SB5SND **19-21.** **19**	**YANKEE RADIO CLUB INC.** — Oxford County Fairgrounds, Rt. 26, Oxford, ME **20.** **RARITAN VALLEY RADIO CLUB 10th ANNUAL HAMFEST & FLEA MARKET** — Columbia Park, Dunellen, NJ **20.** **ATLANTA HAM FESTIVAL 1981** — Downtown Marriott Hotel, Atlanta, GA — W4GKF **20-21.** **ARRL CONVENTION** — Georgia State, Atlanta, GA **20-21.** **20**
JACKSONVILLE ARC 16th ANNUAL HAMFEST & FLEA MARKET — Morgan Co. Fair Grounds, Jacksonville, IL — WB9RAL/WD9EBK **21.** **LANCASTER & FAIRFIELD COUNTY ARC 1981 FAMILY HAMFEST** — The P & P Barn 4 miles West of Lancaster off Rt. 188 — WB8VOA **21.** **LAKE COUNTY ARC NINTH ANNUAL HAMFEST** — Lake County Fairgrounds, Crown Point, IN — KA9COM **21.** **21**	**22**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **23**	**24**	**25**	**26**	**ARRL FIELD DAY 27-28.** **27**
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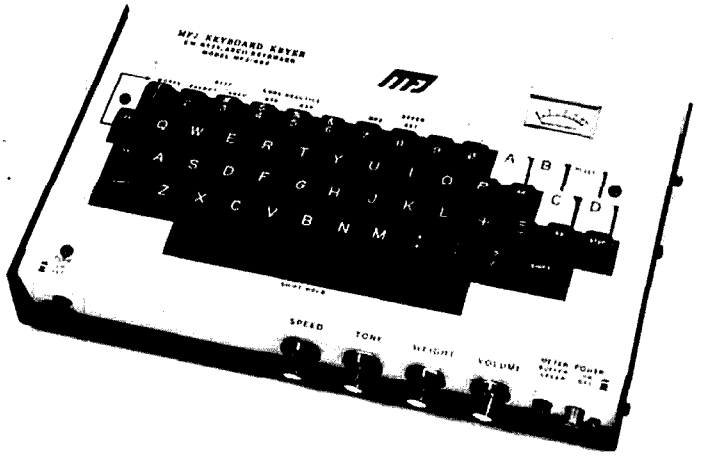
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off. The MFJ-494 operates on 9-12 Vdc or 110 Vac with optional ac adapter ($7.95). The same ultra reliable keying circuit that MFJ keyers are famous for is used in the MFJ-494. If ordered from MFJ there is a 30-day, money-back trial period. If you are not satisfied, you may return it within 30 days for a full refund (less shipping). MFJ also provides a one-year unconditional warranty. To order call toll free (800) 647-1800, or mail order with a check or money order to MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, Mississippi 39762.

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Kantronics Mini-Reader is the size of a hand-held calculator (5.75 inches by 3.5 inches by 1 inch). The Mini-Reader reads and displays Morse code, radioteletype (at any shift or standard speed), and ASCII computer language. It computes and displays code speed, automatically tracks Morse code speed from 3 to 80 WPM, maintains lapse or real time on a 24-hour clock, and contains both an audio frequency counter (0-79 kHz) and a 250-Hz audio filter. The Mini-Reader operates on 8 to 18 volts dc.

The Mini-Reader opens a world of Morse conversations, Amateur radioteletype exchanges, UPI and AP news bulletins, official weather bulletins and warnings, ship-to-shore calls, special maritime bulletins, and on-the-air computer exchanges.

The Mini-Reader comes wired, tested and warranted for a full year for only $314.95, suggested retail price. Write to Kantronics, Incorporated, 1202 East 23rd Street, Lawrence, Kansas 66044.

solder repair kit

A line of solder repair kits for making fast, easy repairs on a variety of electrical and electronic connections in the home or workshop is available from Fry Metals, Inc., of Providence, Rhode Island.

Fry Solder Repair kits feature triple-core solder dispensers that ensure continuous flux flow while soldering fine wires and other connections. They are offered in both 60 percent tin/40 percent lead, and 40/60 combination rosin dispensers; also included is a handy pre-mixed solder cream dispenser tube.

Fry Solder Repair kits range in price from $1.30 to $4.50. For more information contact Fry Metals, Inc., 50 Sims Avenue, Providence, Rhode Island 02909.

receiver preamplifier

Palomar Engineers announces a new receiver preamplifier which is continuously tunable and covers the short wave bands from 1.8 to 54 MHz. It provides 20 dB gain with a dual gate FET for low noise figure. The gain and the low noise figure greatly improve reception on most receivers, particularly on the higher frequency bands. The added selectivity reduces image and spurious response.

Gain is continuously variable to prevent overloading the receiver. A step attenuator is also provided along with a selector switch for two antennas. Model P-305 operates from a 9-volt battery and is priced at $99.95. Model P-308 has a built-in 115-volt ac power supply and is priced at $109.95.

For a free descriptive brochure write Palomar Engineers, 1520 G Industrial Avenue, Escondido, California 92025.

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A new line of precision aluminum boxes for electronic packaging, which can be made in any size with no tooling or set up charges, are available from Nordal. The box and removable cover are made of 0.032 aluminum. These boxes can be used to package RF circuits, amplifiers, filters, oscillators, magnetics and other

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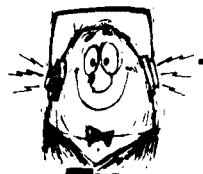
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electronic circuits. The boxes can be used alone or mounted on a PC board to provide a shielded package with a removable cover.

Write Nordal Electronics Company, 9995 Monroe Drive #205, P.O. Box 20175, Dallas, Texas 75220.

multiple signal line protectors

A complete line of signal line protectors has been introduced by MCG Electronics. These devices provide complete interface protection for signal/data/telephone lines; they protect two-wire systems and RS232, RS423, RS422 systems.

Models are available that can protect as few as two independent twisted pairs. Housed in compact low-profile cases, all protectors can be installed by simply using a screwdriver.

Applications include modems, computers, peripheral equipment, semiconductor devices, as well as all other sensitive equipment that interfaces directly with telephone or signal lines.

The units were designed specifically to protect signal/data/telephone lines from transient overvoltages caused by lightning, heavy machinery, elevator motors, and generators. The protectors interface between the signal lines and the sensitive circuit that is to be protected. All protectors recover automatically to standby in preparation for further protection.

Prices start at $59. Write MCG, 160 Brook Avenue, Deer Park, New York 11729.

EZ CORD

Colton Creators, Inc., has developed and patented a product for safely holding electrical cords. EZ CORD CONTROL holds all sizes of extension cords, amplifier cords, and other wires that can become a safety problem. EZ CORD CONTROL eliminates tangles and offers a safe solution to the hazards created by unwound extension cords. It is portable, and can also be mounted for use or storage.

Practical uses include all lawn and garden equipment, power tools and appliances, microphones, battery cables, speaker and amplifier cables, drop light, and pool filter. It is also ideal for holding yarn, clothes lines, Christmas lights, ski tow ropes, mooring lines and anchor lines. Priced under $3.00. Write Colton Creators, Inc., 216 East Second Street, Mineola, New York 11501.

short circuits

satellite bearings

In the article "Geostationary Satellite Bearings with the TI-58/59 Programmable Calculator," which appeared in the April, 1981, issue, the following corrections should be made to the program: Line 028 should be 86 STF and use instructions steps 5 and 7 should display 23.2. Step 6 should display 252.8.

synthesizer

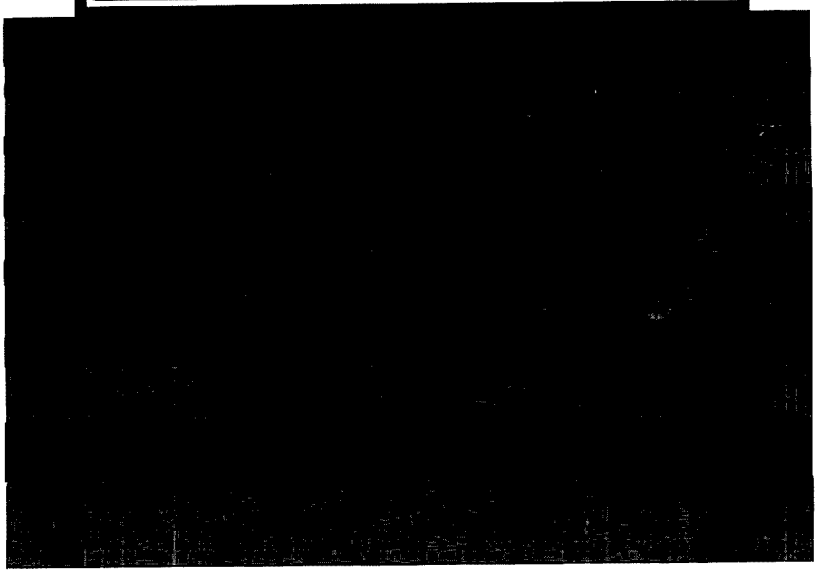
The following corrections should be made to the schematic in the article "Genesis of a Synthesizer," which appeared in the March, 1981, issue: The 2N2369 whose collector is connected to pins 9 and 10 of U15 is Q2; the other transistor inadventently marked "Q2" should be labelled Q3. The collector and base of Q3 should not be connected together. The connections between the 0.1 MHz thumbwheel switch and U10 are as follows: 8 to pin 6; 4 to pin 4; 2 to pin 2; and 1 to pin 14. The input to U8 should be on pin 6, not 8. "PE" of the left half of U4 and "PE_{out}" on the right are connected internally to pin 1 of U4. The input to pin 15 of U15 should be $\approx$25 MHz.

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JULY 1981

volume 14, number 7

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by Skip Tenney

The verdict is starting to roll in and it looks like a good one. As I write this several weeks before you see it, we're already starting to receive a number of our readers' questionnaires from the June issue. Thus far, an overwhelming majority of both *ham radio* and former HORIZONS readers have told us that they like our new combined magazine as well as or even better than before. Your comments have not come without some good criticism, but overall the consensus is quite positive.

After meeting with many of you at hamfests, club meetings, and in the course of our normal business activities we had felt that this would be the case. However, as good as intuition may be, it is very reassuring to know for sure that you are on the right course. Equally reassuring, if not even a bit more so, is the news from our accounting department. After over two years of almost consistent bad news, primarily caused by Ham Radio HORIZONS, we have been in the black since the first of February. It's quite exciting to have the whole *ham radio* organization back on a solid footing once again.

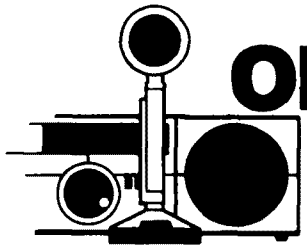
I'm sure you have already noted the thicker magazine we have been able to put out several times already this year, thanks to our good response from advertisers. Not only will this mean more pages, but it will also allow us to add some excellent new features in the months ahead. For instance, in September we will be introducing a new license upgrading series by Robert Shrader, W6BNB. Bob's book, "Electronic Communication," published by McGraw-Hill, now in its fourth edition, has become the leading authority in both the commercial and Amateur license study field. Bob will be putting all his great experience in this area to work for you, and I'm sure you'll find this one of the most readable and rewarding parts of our magazine each month.

In addition to a number of other good ideas that our own staff has been working on, you readers have given us a considerable number of new projects that are worthy of serious thought. We are finding a lot of excellent suggestions being enclosed with the many questionnaires we have received so far. Of course, these questionnaires are just starting to roll in now, so we'll probably really have our hands full in another week or so when we are looking at several times the number currently on my desk.

While we are on the subject of the questionnaire I'd like to ask again that if you have not already filled it out, why not take a few moments to turn to page 49 of our June issue and give us your thoughts on *ham radio*'s new look. It's not often that you get an opportunity like this to help guide the future of what we hope is your favorite magazine.

In closing I'd like to thank all of you for your encouragement and support during our rather difficult transition period. It would have been a much greater task for all of us here at *ham radio* if we didn't feel that you were behind us in our efforts to bring you the very best magazine in Amateur Radio today.

Skip Tenney, W1NLB



Observation & Opinion

This month we welcome a guest editorial by well-known DXer and author Bob Locher, W9KNI, who has a few words to say about today's Amateur transceivers. You, also, are encouraged to offer your observations and opinions. Those we consider to be in the best interest of Amateur Radio will be selected for future issues. Please type your material on 8-1/2 by 11-inch paper, double spaced, with 2-inch margins.

I would like to remind readers who have not already done so to please complete the readers' survey form that appeared in last month's issue. We need your input.

Alf Wilson, W6NIF, Editor

In most respects, the state of the art of Amateur Radio equipment achieved the high-frequency operator's requirements around 1954, with the introduction of the Collins 75A-4/KWS-1 combination. These big black boxes were stable, with repeatable frequency readout to less than one-half kHz. They offered outstanding performance on SSB and CW, were reliable, and were a joy to operate. In fact, a lot of them are still in active service.

On the other hand they were large, expensive, did not offer transceive capability, and depended on "hollow state" technology. But they established a new benchmark of performance for Amateur equipment and inspired a succession of fine equipment, both from Collins and other manufacturers. Phone operators never had it so good.

Neither did CW operators. At last — stable receivers; stable enough to make really sharp CW filters usable — and a new generation of fine CW filters as well! And, stable transmitter VFOs whose outputs stayed put. Use of heterodyne techniques instead of multiplier VFOs made CW signals clean and chirp free, even on 10 meters.

The new SSB rigs required a new kind of amplifier, called a linear, and the old push-pull pair of 250THs was obsolete. The new linears worked well on CW too, and didn't affect keying characteristics as did the old class C amplifiers; and they even had less TVI! The late fifties were great days for CW ops for sure, thanks to all that new SSB gear.

But then equipment design began to change. Collins brought out the KWM-1, and the dawn of the transceiver age arrived. It is certainly unnecessary to detail the success of this concept in high-frequency equipment. The convenience of operation for SSB and the reduction in costs and size made the concept a huge success.

In design, the early transceivers treated CW purely as an afterthought. There was no provision for CW filters in the receiver section, nor was there any provision for moving the frequency of the receiver slightly to accommodate different offsets. Little thought was given to waveform shaping of the keyed output. In justice, however, all the manufacturers of these transceivers also offered separate receiver/transmitter combinations that made fine CW equipment.

Then, transceiver sales began to far outstrip sales of separates, largely due to economic considerations — a transceiver cost little more than a receiver *or* a transmitter. In response, the more enterprising suppliers offered provision for CW filters in their transceivers and began to pay attention to the keyed waveform output. About this same time, paired separate receiver/transmitter combinations were discontinued, and this is pretty much where we find ourselves today.

The current generation of transceivers, with few exceptions, have no capability for accurate zero-beating of another CW signal. The most guidance generally given is what the receiver offset is, if no receiver incremental tuning is in use. Beyond that, you're on your own.

What is the result of this? We have CW QSOs where the two stations walk up the band in tandem, each recentering the other in his receiver at each over. CW ops using transceivers usually end up getting creamed in pileups, because they can't accurately place their transmitted frequency. Even worse, many CW QSOs use two frequencies, separated by as much as 500 Hz, when only a single frequency is needed; but the transceiver-equipped operators can't find it. Obviously, this causes QRM.

Today, we even have a situation where two major manufacturers offer separate receivers matched to their transceivers, but with absolutely no realistic way to zero the transceiver's output in the "matching" receiver. What, then, is the value of the separate receiver?

There *are* ways to cure these deficiencies. The simplest technique is to see that the audio CW monitor is precisely equal in frequency to the differential frequency of the offset used between the transmitted and received frequency, with provision to key the monitor only. This is the method offered in the new Collins KWM-380.

A deluxe technique that would make transceivers as useful on CW as separates would be to make variable both the frequency of the CW monitor and the offset differential, with perfect tracking, so that the audio monitor only could be keyed, and then adjusted to zero beat the received station precisely. The additional cost would be negligible, and these techniques would work equally well with outboard VFOs.

Bob Locher, W9KNI



comments

protecting Amateur Radio

Dear **HR**:

Where are the hams with legal training, lawyers who understand electronics and who have a desire to serve the Amateur community while possibly making a buck, who have imagination and verve?

It was depressing to read in *ham radio*, March, 1981, a brief statement concerning an Amateur who had been sued by a neighbor for causing interference in the neighbor's stereo. The Amateur was ordered by a judge to cease operation. This item seems quite newsworthy to the Amateur community, but it happened in 1977 and I had not previously been aware of it.*

Some of us have heard of situations where hams have been forced to choose between giving up the hobby or spending large amounts in legal fees to fight for their rights, but there has been no communication of the facts to Amateurs on a current, national basis. Those situations evidently arise infrequently and in widely scattered areas so none of us know the full story. We need to become aware before many legal rulings become precedent setting, adversely affecting all of us. What is needed is a central clearing house where hams experiencing problems can seek and find relief through action taken by professionals in the fields of electronics and law. If every ham were to participate, the necessary supporting fee would be very low, and every ham could be encouraged to participate regardless of affiliation or lack of affiliation in any other organization. We must all stand together. If support were denied to any ham, and he were to lose in court, undesirable precedents could adversely affect all hams.

In organizing there can be great strength, to wit, the National Rifle Association. We need such strength to protect us from the avarice of manufacturers who could build stereos immune to interference but reject that idea as too costly. Remember the rampant TVI problems of years ago? Nearly non-existent now, in part because of improved TV receivers.

If the logic used by the judge ordering an Amateur to cease operations were to be carried to its ultimate, we could shut down the airlines. At least, they come in 5 by 9 in my stereo.

We need to become organized. Won't someone take the initiative?

Donald E. Thomas, K2JIY
Millville, New Jersey

Two organizations are available to help Amateurs with legal problems related to Amateur Radio: the ARRL through its Membership Services section and the Personal Communications Foundation (PCF), which provides an Amateur's attorney with information pertaining to the Amateur's problem. This information is furnished by attorneys who are members of the PCF. The PCF may be reached through Mr. Joe Merdler, Suite 203, 9036 Reseda Blvd., P.O. Box 812 Northridge, CA 91328. The phone number is (213) 349-6950.

*A subscription to *HR Report*, issued every two weeks, will keep you posted on the latest happenings in Amateur Radio. **Editor**

county awards

Dear **HR**:

I am the Western States county award manager for the CHC award program. The CHC award program is active again through the efforts of interested Amateurs now assuming various responsibilities since the death of the former manager, Cliff Evans, K6BX.

The Western States part of the county award program encompasses Alaska, Hawaii, California, Oregon, Washington, Nevada, Arizona, Utah, Idaho, Wyoming, and Montana. The awards are available to both licensed Amateurs and SWLs.

Also available are the 10K and 20K U.S. Pacific awards, which are issued for confirmed contacts with 10, 20, or more of those prefixes issued to Amateurs in the islands under the jurisdiction of the U.S.A.

Another fine award is our version of the A-1 operator award. This is quite different from the ARRL A-1 Operators' Club, and is structured to allow recognition of superior Amateur operating practice by any three Amateurs.

Details on these and other awards in the program are available for an SASE to Scott R. Douglas, Jr., KB7SB, Post Office Box 46032, Los Angeles, California 90046.

We hope to hear from you.

Scott R. Douglas, Jr., KB7SB
Los Angeles, California

good work

Dear **HR**:

I am surprised about your combined magazines. It will be great if some of the really good features of *HORIZONS* are put in your magazine, like DXer's Diary, and mixed-general ham radio and technical features.

I am looking forward to getting your great magazine!

Donald Youtkus, KA2GSX
Scotch Plains, New Jersey

wearing cans

Dear **HR**:

I'm writing in reference to the article on better audio for mobile operation that appeared in *ham radio*, February, 1981, pages 48-49. Although reference is made to some headphones, such as Sennheiser, not blocking out road noises, I think your magazine should point out that in many states (including Illinois) it is illegal to drive an automobile while wearing headphones (whether they block out road noises or not). Readers should be warned to check local and state laws before setting out wearing "cans."

Ken Van Andel, WB9FRV
Aurora, Illinois

presstop

ARRL'S BOGUS-QSL INVESTIGATION continues, with three DXers now suspended from the DXCC program. A prominent DXpeditioner has resigned from DXCC, and still others are being checked for apparently submitting questionable cards for credit.

Phoney DX Cards First Attracted the attention of DXCC program manager W3AZD late last year. Photocopies of questionable cards, with the submitter's call blocked out, were sent to the DX station or his manager along with a request for a list of the stations worked around the time shown. Not only did the submitter's call not appear in that list, but some of the DX stations even responded with "not on that band...or mode...or even on the air" at the time shown, and further commented the writing was not theirs or any assistant's.

Bogus Cards For About two dozen different rare DX stations have thus far shown up in Newington, though there have been claims that far more than that have been printed. Most are for stations who were active in the 60s or early 70s, though a few are current. The one DXer whose suspension is definitely related to the counterfeits is W6NZX. Two Europeans, whose calls have not been announced, have also been suspended but for alterations or other apparently unrelated QSL questions. The DXpeditioner who is resigning is Dr. Dave Gardner, K6LPL, who discussed his involvement freely in a telephone conversation with HR Report.

K6LPL Said The Bogus Card Idea began at an informal meeting of a dozen or so DXers (including a number of Honor Roll Members) at the 1980 Fresno DX convention. Several were also DXpeditioners and all agreed that DXing was in a sad state with pursuit of QSLs an obsession. Cheating was rampant, they felt, yet the ARRL had seemed unresponsive to calls for change. Then they hit on the idea of wholesale counterfeiting of rare cards, as a means of demonstrating the present system's weakness. Dave believes at least 20,000 of the phoney cards were printed, and they've been passed out by both U.S. and overseas Amateurs to hundreds of others. Because of his part in the scheme, he has now submitted his letter of resignation to DXCC to the ARRL.

Just How Many DXers Will eventually be involved is still to be determined. In the meantime, all DXers are warned to beware of cards from long past contacts or coming from unusual sources.

AMATEURS SERVING AS POLICE "eyes and ears" in a Los Angeles Police Department project found themselves providing needed communications in a kidnapping/shooting incident on May 8th. The volunteer program, operating just over a month, puts Amateurs with hand-helds at vantage points in likely crime areas. They report suspicious activities to others riding in prowl cars for follow-up. Thus far they've broken up one attempted rape and reported several possible car break-ins.

The Episode On May 8th Began when four Amateurs and a police advisor, atop the Hollywood Holiday Inn, heard shots fired from a room just beneath them. Police from various agencies, converging on the scene, found an immediate problem with a lack of common communications frequencies and portables. The Amateurs stepped into the breach, providing coordinating communications for several hours during negotiations with the gunman, who was holding a girl hostage in his room. Eventually she escaped, and early the next morning the gunman apparently shot himself.

160 METER POWER LIMITS will be lifted shortly, at least on the bottom half of the band. At its May 21 agenda meeting the Commissioners agreed to restore full privileges to 1800-1900 kHz now that Loran A is phased out in the U.S. However, since Canada is still using Loran A above 1900 kHz, the present restrictions must remain in effect on the top half for the time being.

Effective Date For The Relaxation has not yet been announced, but should be sometime early in the summer.

10 MHZ SHOULD BE RESERVED for narrow-band (CW and RTTY) Amateur use only, the 200 Amateurs attending the Region 1 IARU conference in Brighton, England, generally agreed late in April. A couple of nations, however, still want SSB on the new band. Representatives of IARU member societies from around the world attended the busy four-and-a-half-day session. The meeting saw the best turnout ever of African IARU representatives.

Contests Should Also Be Kept Off the new 30-meter band, the conference agreed, though unlike the ARRL the Region 1 societies felt that awards for 10-MHz operating achievements would be OK. They also agreed on SSB for the new 18- and 24-MHz bands, with narrow-band modes taking the bottom half and phone the top. A new satellite working group was also established and satellite band plans set up.

10-GHZ MOBILE OPERATION has been demonstrated by three Canadian Amateurs, VE2DWG, VE2FMF, and VE2FRJ. The first contact was made back in February, and even with antennas inside the cars usable signals were found at distances up to a mile despite intervening buildings and other autos. Doppler shift was quite noticeable, however.

FSK adapter for SSB transmitters

An easy method for exploring RTTY

I wanted a new mode of operation for my station. I've been thinking about a microcomputer for both domestic and radio use, and two recent FCC rulings made me interested in RTTY.

My station was designed for SSB or CW only, but there should be a way to operate RTTY using an audio modulator-demodulator, or modem. The following article describes how I did it. I hope others will follow suit.

the modem

The FCC now allows ASCII seven-bit code on high-frequency Amateur bands at 110 or 300 Baud.* ASCII is similar to the five-bit Baudot code of mechanical teleprinters, but has the advantage of being able to communicate with all modern computer systems for character transmission. This might be a breakthrough for Amateurs who want to use their computers for communicating rather than for the more conventional purposes of logging, satellite tracking, or home games.

I decided to build a modem that would make possible FSK using my SSB equipment. I'd read that some Amateurs use audio tones for FSK, and so an audio modem seemed a good route. A keyboard for character generation and a CRT display would complete the FSK adaptation. This would work with either ASCII or Baudot.

The second FCC ruling on F1 emissions indicated that this was the correct choice. F1 emissions are allowed on high-frequency bands, but the ruling states that audio tones into the audio input of a single-sideband transmitter must have good carrier and unwanted sideband suppression to qualify for F1 emission. Certain precautions would be required to meet these criteria.

This article concerns the modem design and describes how to incorporate the modem into a complete video terminal for either ASCII or Baudot. Such a system could eventually lead to exchanging computer programs over the air.

design concepts

Modem design began with the following primary goals:

1. Use a single 5-volt power supply.
2. Use a minimum number of ICs.
3. Use TTL-compatible interfaces for expansion.
4. Use audio-frequency operation for standard SSB equipment input and output.

The demodulator is a single chip made for this purpose, an Exar XR-2211 demodulator/tone decoder. It contains a preamp, phase locked loop (PLL), and comparators. Preamp dynamic range guarantees tracking with 3 mV - 3 volt rms input levels. Center frequency, bandwidth, and output delay are inde-

*ASCII is an acronym for "American Standard Code for Information Interchange." A Baud equals bits per second in this code.

By Thomas B. Zeltwanger, WA3PLC, Box 62, State College, Pennsylvania 16801

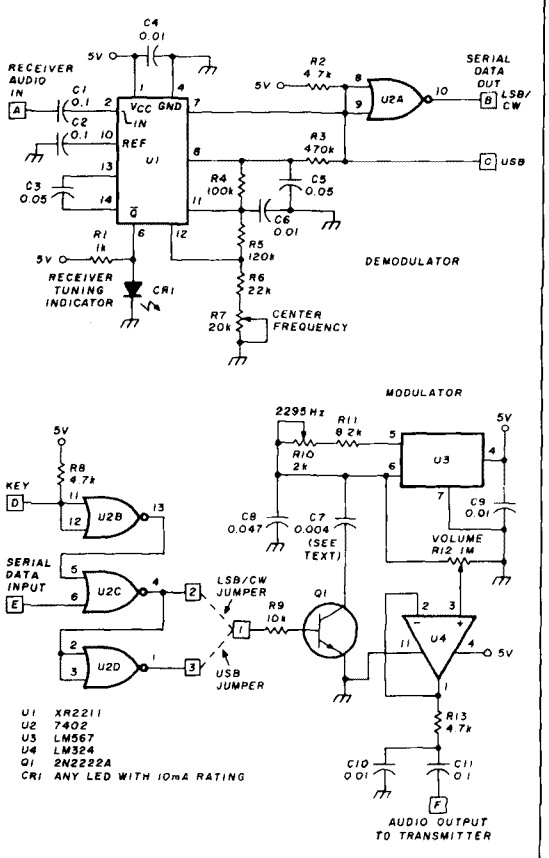


fig. 1. Modem schematic diagram.

pendently set; breadboarding and alignment are very easy.

Receiver audio output is connected to the audio input, **A**, of **fig. 1**. Normal FSK *shift* frequency is 170 Hz, so a CW receiver filter worked best. Its narrow bandwidth reduces noise and allows the demodulator to track the audio mark and space tones faithfully. Different receiver filters may require different center frequency adjustments (R7). Demodulator center frequency is given by:

$$f_0 = \frac{1}{C3(R6+R7)} \qquad (1)$$

All values are in Hz, farads, and ohms. (I started with 900-Hz center frequency but had to decrease this to 750 Hz for my receiver.)

Tracking bandwidth for shift frequency f_s is determined by R5 and is given by:

$$R5 = (R6+R7)(f_0/f_s) \qquad (2)$$

Other values were taken from the XR-2211 specification sheet. A useful feature is the PLL lock signal: A LED connected to pin 6 is used for a tuning indicator. Serial-data output goes to the video board and is explained later.

modulator section

The current-controlled oscillator section of an LM567 tone decoder, U3, generates mark and space tones of 2125 and 2295 Hz. C8, R10, and R11 set the 2295-Hz frequency with Q1 cut off. When Q1 is conducting, C7 is in parallel with C8, and the frequency shifts down by 170 Hz. C7 may have to be trimmed slightly for the correct shift.

Ideally, a pure sine wave should be used for modulation. U3 produces a triangular waveform. A triangular shape, or any continuous waveform, can be thought of as a combination of harmonics differing in amplitude and phase. A triangular waveform can be expressed by the Fourier series:

$$V = \sum_{i}^{\infty} \frac{A}{i^2} \sin(i\omega_0 t) \qquad (3)$$

where:

i = 1, 3, 5, 7,...(harmonics, 1 = fundamental)

A = normalized peak amplitude of fundamental signal

$\omega_0 = 2\pi f_0$ = radian frequency of fundamental signal

$t = 1/f_0$ = period of waveform

The triangular waveshape is composed of the fundamental and odd harmonics. Calculation indicates that the third harmonic of 2125 Hz is 1/9th the power level of the fundamental, or down 9.5 dB.

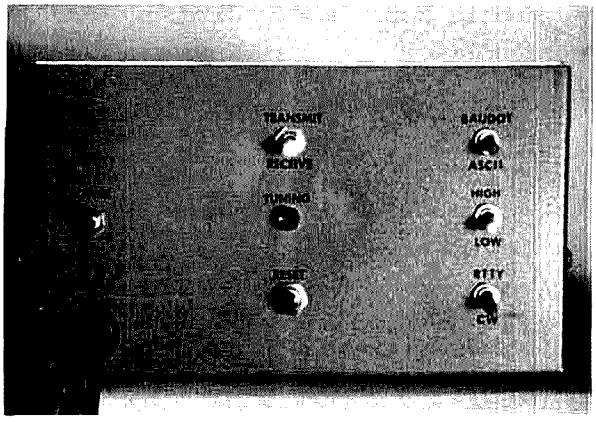
Buffer amplifier U4 isolates the oscillator and provides a means of setting transmitter audio input level. Legal operating practice requires a bandwidth under 3 kHz. The RC lowpass filter, R13, C10, smooths harmonics; the −3 dB point is at 3386 Hz.

calibration

The modulator must be calibrated with a frequency counter or accurate oscilloscope. With Q1 cut off, R10 is set for a 2295-Hz tone. With Q1 conducting through the serial-data input gate (input ground, output to Q1 base high), a value of C7 is found to lower the tone to *exactly* 2125 Hz.

My calculations indicated a 0.0037-μF cap should do the job. A 0.005-μF was tried, but the shift was too great, according to one Amateur with a tunable i-f filter. A 0.0015- and 0.0022-pF cap in parallel worked fine.*

*A high-value mica padder capacitor from the junkbox would be ideal for this trimming. **Editor**



Front panel of the modem box. All switches are accessible. A tuning indicator is included, which is helpful when receiving narrowband signals on RTTY.

Volume control level R12 should be set for an equivalent-to-strong voice input. Adjust this pot with caution, since the RTTY duty cycle is 100 percent and can strain the final. It's the same as CW operation with the key held down continuously. I turn down the drive power input; the final still runs very warm.

Demodulator center-frequency adjust pot, R7, is the only adjustment used for receiving. Tune the receiver so that both FSK tones are in the receiver passband. Adjust R7 for maximum LED intensity or until characters are visible on the monitor screen.

operation

Best reception is obtained with the narrowest receiver filter available. I use a 500-Hz i-f filter and CW mode — sometimes with an additional audio filter. Transmission must occur in the sideband mode.

Provisions have been included for inverting the FSK tones, as indicated by the jumpers and alternate data outputs in **fig. 1**. (This is required for frequency offsets and filter bandwidths in different receivers and transmitters.)

Upper sideband mode was first tried for both transmitting and receiving, but I couldn't use my 500-Hz receiver filter in the SSB mode. Reception is now in CW mode, and transmission is on lower sideband. I offset-tune the receiver to zero-beat received signals. Tones are "right-side-up" in CW/LSB; that is, the higher tone is higher on the dial; they are inverted when using USB. Keep this in mind, because the demodulator will be working fine but printing will be garbled.

In CW/LSB, the idle (mark) tone will be lower in frequency, and jumper 1-2 is used. Demodulated output is taken from B (fig. 1).

test results

On-the-air tests have been encouraging. The narrow receiver bandwidth makes tuning somewhat critical but is eased appreciably by the LED indicator. After a few hours' experience, I became familiar with the response and had no real problems.

Very weak stations can be copied, but the PLL tends to unlock from noise. I've copied strong stations in 60 wpm Baudot for as long as an hour and a half with no loss of information. At higher Baud rates, the noise on 40 meters becomes a problem, but copy is still possible. I've also copied ASCII at 110 Baud on 20 meters.

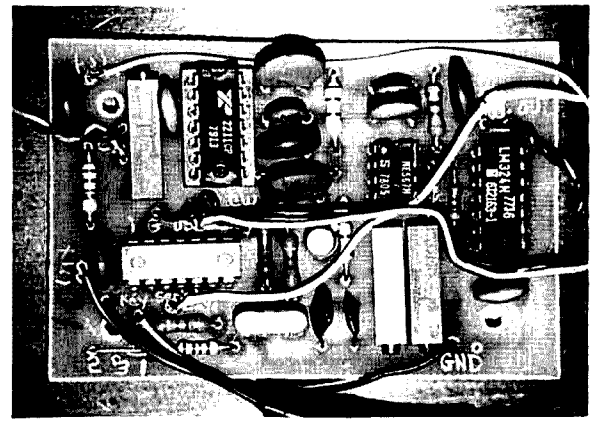
ASCII reception was over 95 percent error-free under normal circumstances. Most RTTY on the hf bands has been heard between 14.075 and 14.100 MHz, including many DX stations. I have not yet heard anyone using 300-Baud ASCII.

some uses

The modem will interface with any TTL-compatible serial video terminal. It can also be used with a teleprinter to replace an RTTY converter; input and output must be modified for the 20-mA current loop in teleprinters.

Keyboards are readily available from surplus dealers for under $50. Video monitors with 12-MHz minimum bandwidth may be used for the display. The most expensive part of my FSK system is the video board.

Video boards are made in many configurations. The one I used is the Xitex SCT-100 and seems to have been designed with the Amateur operator in mind. It's capable of both ASCII and Baudot operation; its speeds are 60 and 100 wpm in Baudot, 110 or 300 baud in ASCII. It may be purchased in kit form or fully assembled.



Printed-circuit board of the FSK modem. The two ICs at left make up a computer interface, allowing the video terminal to be used on the air or as a computer console.

A block diagram of my terminal system is shown in **fig. 2**. The modem is installed between the video board and all other equipment. The "key" is any switch connected to terminal **D** in **fig. 1**, and is used for calibrating the modulator tones.

The same system, less transmitter and receiver, has been used as a microprocessor terminal with no problems. Future applications will include the addition of a cassette tape, instead of paper tape, for

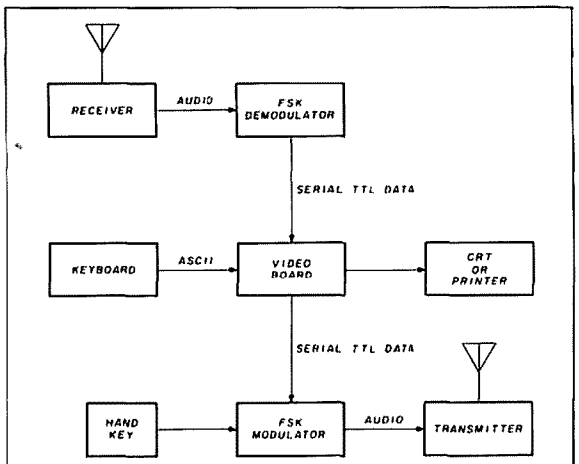


fig. 2. System block diagram.

prerecorded messages. Limited tests indicate that this is feasible.

some final thoughts

My system works well but my station is in an apartment, with the antenna about ten feet (3 meters) from my rig. Rf shielding was a problem, because the video board generates a lot of RFI on 20 meters. I've heard the same complaint from others using computers on RTTY. Tests at another location indicated that RFI is minimal with the antenna farther away from the transmitter.

PC boards are available from the author for $5.00 plus postage. All circuit components are readily available from hobby dealers.

I'd like to extend special thanks to K4YI and KØWVN, who were very helpful with my first on-the-air tests.

video board suppliers

Xitex Corporation (manufacturer), 13628 Neutron, Box 402110, Dallas, Texas 75240. Mini Micro Mart, Incorporated, (distributor), 1618 James Street, Syracuse, New York 13202.

ham radio

Hatry Electronics

500 Ledyard St. (South) Hartford, Ct. 06114

203-527-1881 (Ask for Ham Dept.)

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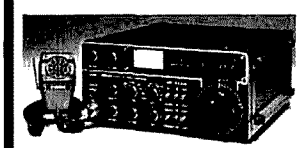


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Drake	Unadilla/Reyco
Gold Line	Valor
Ham-Key	Van Gorden Engineering
Hayden	Vibroplex
Hustler	W2AU
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SHIPPING F.O.B. HARTFORD COD

Solid advice
for
mail-order buyers

shopping for parts by mail

To many **hams**, buying parts simply means a trip to the local franchised radio store, where the counter salesman is given a parts list to fill. All too often, however, the enthusiasm for your latest project is spoiled either by "out-of-stock," or by high prices. The instant-delivery convenience of the round-the-corner radio store is frequently paid for in great cost of both dollars and wasted time.

What to do? It's a good idea to *preplan* construction projects far in advance; to develop a complete parts list, with a breakdown into separate lists — those that are best filled by mail-order means, and those that are best filled locally.

I'm not knocking local buying; there are many occasions when it *is* best to shop locally. I'll cover the development and breakout of parts lists for mailorder purchase, present some tips on making parts substitutions, offer some general mail-order buying hints, and discuss the pros and cons of buying in advance of needs. Also I'll discuss the problem of component identification.

The list: getting it together

Most published construction projects include an itemized parts list that states each part's nomenclature, size, value, required voltage, current, or power-handling capacity, and other necessary information. Some projects even list brand names and recommended sources for difficult-to-obtain components.

The basic parts list can be broken down in several ways — by type of component, or — in the way I prefer — into two lists: by parts that are best locally procured, and by those that are best acquired by mail order. The two lists can be broken down *again* by type component to facilitate shopping and ordering. You must know something about the electronic marketplace to set up the lists, of course, and it helps to have on hand a generous selection of current catalogs and flyers to sort out which components should go on which list.

Having a good-size pile of catalogs will enable you to find almost any desired part in one of them and will often allow you to locate a single mail-order firm that may have all, or nearly all, of what you need. Having a variety of catalogs also allows you to easily make price comparisons.

Table 1 is a list of *dealers*. Many offer *free catalogs* that can be obtained by filling out the reader service cards found in electronic and Amateur-Radio magazines.

After thoroughly checking your *junkbox*, the buy-local list is used first, so that out-of-stock items can be identified and added to the mail-order list. You'll want to at least scan the mail-order flyers and check out *local sales* and *hamfests* to see if any *bargains* turn up that would suggest switching an item from one list to the other. It pays, too, to consolidate mail-order "buys," due to steep postage charges, minimum order limits, and handling fees. The word is: plan ahead.

By Karl Thurber, Jr., W8FX, 317 Poplar Drive, Millbrook, Alabama 36054

parts substitution

This discussion leads to the question of substituting components. It's especially important when it comes to buying by mail, since it's inconvenient, time-consuming, and expensive to return wrong-choice components — not to mention the frustration involved. It's a fact that most small parts that aren't right usually end up in the junkbox, since it's normally not worth the effort to return them — and what's in the junkbox is seldom what's needed for a given project.

over-rated components

Generally speaking, over-rated parts can be used in electronic projects. For example, a 1-watt carbon resistor can be used instead of a ½-watt carbon resistor of the same resistance. A 100-volt, 0.01 microfarad Mylar capacitor can be used in place of a lesser-rated one, such as a 25-volt, 0.01 microfarad Mylar, assuming that the tolerance range (usually ± 10 or 20 per cent) is maintained and that the larger component will physically fit its allotted space. Both resistors and capacitors can be connected in parallel or series to yield new values. And what about those confusing decimal equivalents? **Table 2** shows popular electronic metric conversions you'll need. Get them right when shopping by mail!

Be careful when substituting components with over-rated ones when the device is supposed to perform a *specific function* at a certain value of voltage or current. In this case, a larger unit would not do the job. Zeners and other voltage- or current-regulating devices would fall into this category.

active components

As for active components, similar guidelines hold, as long as the substitute has equivalent parameters. For example, a transistor that has a maximum collector current (I_C) of 600 mA can be used as a substitute for one having a maximum I_C of 400 mA, providing that other specifications are comparable — such as power dissipation, current gain, maximum collector voltage and frequency.

literature

It pays to have a set of semiconductor reference books to enable quick substitution decisions. With so many construction projects stated in terms of widely-available Radio Shack component types, it's good to have on hand the *Archer Semiconductor Reference Handbook*. This book is a guide to Radio Shack's semiconductors and it's also a useful cross-reference and substitution guide for over 100,000 devices.*

Pin connections and detailed data are provided for ICs, diodes, SCRs, LEDs, and other semiconductors.

Other references are ARRL's *Electronics Data Book* and *Radio Amateur's Handbook*, and Bill Orr's Editors and Engineers *Radio Handbook*, as well as various Sams and TAB substitution handbooks and specifications manuals. Manufacturers' reference books and data sheets are needed if you're really into electronic construction.

The Allied Electronics catalog and engineering reference book is another candidate for your bookshelf.†

table 2. Electronic unit conversions. The following table lists the various multiples and submultiples of fundamental units (such as the farad, henry, watt, etc.). These may be indicated by the following prefixes, *abbreviations and conversion multipliers*:

prefix	abbreviation	multiplier
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico ("micro-micro")	p	10^{-12}

note:
Perhaps the most use for this table will be found in working with capacitor values. Typically, values are stated in terms of microfarads or picofarads ("micro-microfarads"). The latter is one-millionth the former, so an appropriate decimal conversion is required.

For example, to convert the value of a capacitor with a stated capacitance of 0.001 microfarad to picofarads (sometimes called "micro-microfarads"), multiply by 10^6 or 1,000,000. The equivalent value is 1000 pF.

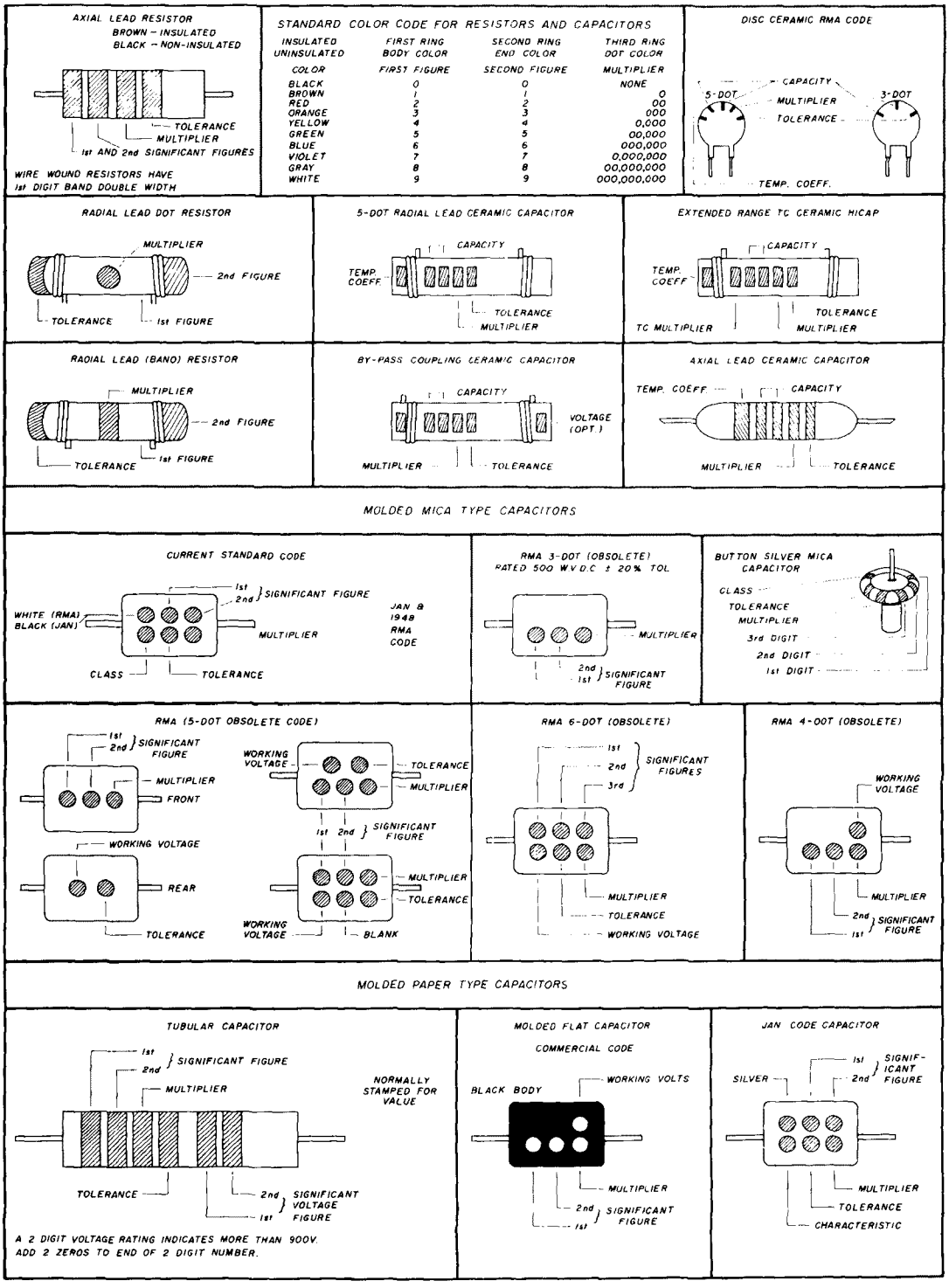
If the equipment designer or article author has pointed out critical components, don't change them! Otherwise, making intelligent substitutions for the exact parts specified is all right. Hams are supposed to be experimenters!

mail-order buying tips

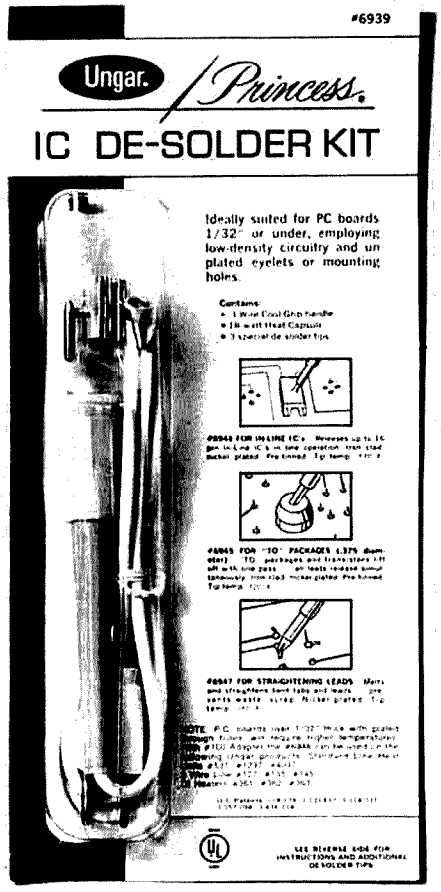
Buying electronic parts and components by mail is no more difficult than buying anything else this way: you write out your order, enclose a check, money order, or charge-card number, and mail it in. In anywhere from a few days upwards, you receive the parts.

*Radio Shack, 1400 One Tandy Center, Fort Worth, Texas 76102.

†Allied Electronics, 401 East 8th St., Fort Worth, Texas 76102.



Most resistors are prominently color-coded for easy identification. This chart should help dispel any confusion as to color-coding schemes.



PC-board-mounted components are usually bargain-priced since it's difficult to economically remove and reuse them. IC desoldering kit shown here has special tools for removal of in-line ICs, "TO" packages, transistors, and also includes a special device that melts and straightens bent tabs and leads to facilitate removal of delicate components, such as diodes (*photo courtesy Ungar Div. Eldon Industries, Inc.*).

A few pointers regarding direct-mail buying are in order. In setting up your list, have a copy of the dealer's latest catalog or flyer at hand, and use one of his order blanks to place you order. Use his part numbers, especially if they are different from, or in addition to, the generic part numbers. Accuracy in stating what you want is paramount!

Be sure to carefully check your arithmetic in pricing the order, and observe minimum-order, postage, handling, and sales-tax requirements. Failure to do so can result in embarrassment and delay. Enclosing a little extra to allow for small price changes or increased postal or UPS charges isn't a bad idea and saves later correspondence. Most firms will refund unused amounts to the penny. For very small orders, ordinary *first class mail* (not parcel post) is quick and inexpensive.

substitutions

If you will accept substitutions in filling your order, so state and indicate the range of acceptable choices, without requiring the order-filler to go through a logic tree to figure out just what is okay with you. State specific "kill" instructions, such as "fill within 10 days or cancel order" or "ship in-stock items and cancel balance of order," or the like. If uncertain as to an item's availability, a phone call or postcard will allow you to check on the stock. If you have questions or correspondence that don't pertain to the order, *place them on a separate sheet of paper to expedite handling*.

consumer protection

There are some important mail-order consumer protections. Since 1975, direct-mail firms have to fill orders within 30 days or offer a refund. If the company can't fill the order within 30 days, or within the time frame promised, you must be sent a return postcard allowing cancellation and offering a refund. There are some exceptions — such as when buying



Industrial and military surplus, represented by this selection of meters and oil-filled capacitors, abounds in the flyers issued by direct-mail dealers. Savings over store prices can be astounding, but a bargain is a bargain only if it can be used. Stock up on the good deals if you like, but exercise care and good judgment in doing so (*W8FX photo*).

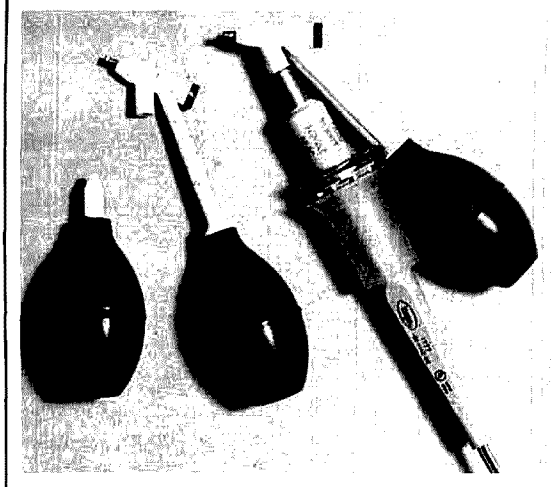
COD — but most merchandise is covered.

If you receive a "dud" part, or have a complaint, contact the company first for adjustment. Most want to please, but salespeople are human, parts do fail, and mistakes can occur. Give them a chance to "right" the situation before becoming aggressive in pursuing your grievance. If doing this doesn't yield satisfaction, you can, as an initial step, fill in a Consumer Service Card (PS Form 4314) at your post office. By completing and returning it, the Postal Service will look into the matter, dealing directly with the company. If fraud is suspected, it may refer the matter to postal inspectors.

What if all you have for the company is a post office box number? You can usually get the name and address of a principal by contacting the magazine that runs the firm's ads. It's also possible to obtain this information on commercial boxholders without charge from postal authorities. Contact your postmaster for help.

telephone orders

Worth noting is the fact that if you place your order over the phone, you do not have the same protection, since you didn't use the mail to place the order. Fraud is still fraud, of course, and fradulent use of the charge card may place the bad-boy firm in other kinds of trouble. Using over-the-phone charge cards is fine, in my opinion, for mail-ordering major items, but ordering large numbers of small components by phone can lead to confusion and mistakes in filling the order. This is especially true if it's a tape recorder that's taking your order.



Buying surplus, component-laden PC boards "just for parts" is fine, if it's recognized that delicate parts such as integrated circuits, transistors, and diodes may be damaged or rendered useless in their removal from the circuit board. Special desoldering tools are required to do the job right, as shown by this array of Ungar gear. Desoldering tool, similar to a regular soldering iron, allows one-hand operation; other hand is free to lift components. The desoldering bulb is shown in three configurations, as a separate attachment, installed on the desoldering tool, and as a separate unit for use with regular irons. Bulb removes solder by a vacuum action (*photo courtesy Ungar Div. of Eldon Industries, Inc.*).



Many direct-mail distributors frequent the hamfest circuit, operating sales tables side-by-side with the individual swapper. If you can't get what you need by mail-order, you may luck out at the next 'fest. Catalogs, flyers, parts specification sheets and bargain lists are always free for the asking. And, hamfests are great places to become familiar with the ins-and-outs of ham radio. Swap meets, technical forums, and dealer displays are staples at most (*photo taken at 1979 Columbus, Georgia Hamfest by W8FX*).

if problems occur

It pays to check out a firm in advance, especially before placing a substantial order. Most of the advertisers in the Amateur and electronics publications are reputable. It's a relatively small, specialized market, and laggards will eventually be driven from business if they offer less than prompt, reliable and honest service. However, if you *do* have problems, you can take several courses of action after trying to resolve matters with the company. You can contact the magazine that ran the company's ads; write state or local consumer agencies; call or write a "consumer action line," such as operated by many newspapers and radio/TV stations; contact the Better Business Bureau; write the state Attorney General; complain to industry or trade associations; or write to the federal Office of Consumer Affairs (Washington, D. C. 20506). You can also contact the Mail Order Action

Line, 6 E. 43rd St., New York, NY 10017, a consumer-assistance program organized by mail-order companies interested in preserving the industry's good name.

in summary

Here are some general mail-order buying guidelines that should contribute to successful results with *a minimum of headaches:*

1. Check out the company and its reputation. Have you seen their ads before? Is there a street address and phone number listed, or just a post office box? *Think* before mailing in your hard-earned dollars.

2. Understand the firm's return policy. Is there a money-back guarantee? What about a restocking charge?

3. Double-check your order before mailing or calling it in. Have you provided a street address? Many firms use UPS for delivery, and they usually need a street address not a post office box number.

4. Send a large-enough remittance. But enclosing a blank check to be filled in with the exact amount by the firm is risky. COD is okay, but these special charges add to the cost of the order. Never send cash. A money order or cashier's check will help speed delivery, as will ordering by charge card.

5. Allow sufficient time to get the merchandise. Realize that it may take a few weeks to clear your personal check, process your order, and actually get the parts to you. On "special deals," look for guaranteed delivery times (and prices) or the caveat, "quantities limited."

6. Always keep a copy or record of your order, showing the date you sent it in, what you ordered, and your check number.

7. Hold onto your charge-account records and cancelled checks. You may need these papers later on. Never send in the originals when inquiring about your order.

8. Many companies routinely issue small refunds in the form of credit slips. If you don't want them, say so in advance on your order form. However, you may want to accept the slips from those firms that allow the slips to be applied to your next order at more than face value, a sort of "consolation" for the out-of-stock problem.

buying in advance: does it pay?

The answer to this question is a crystal-clear "yes and no." A bargain isn't a bargain unless it can be used. The suppliers' catalogs and flyers are filled with bargains — parts by the bagful, manufacturers' seconds, unbranded and unlabeled components, surplus PC boards, and hundreds more — sometimes top-grade components for your next project at prices that are hard to beat, sometimes not. It's best to steer a middle course, taking advantage of quantity discounts and attractive parts "specials" on a highly selective basis, resisting the urge to squirrel-away and stockpile more than you could ever use.

Despite the bargain-filled flyers, direct-mail parts suppliers often have to backorder specific items to the intense displeasure of their customers — you and me. Thus, it's often not a bad idea to pad your order with limited quantities of widely-used chips, transistors and other parts for future use. Doing this is logical when you are trying to build up your order to minimum purchase levels, sometimes $10 or $15 or even more. Also, consider combining club construction project orders and those for friends. Quantity discounts may sometimes be brought into play. Grab-bag specials on assorted parts can help put your junkbox into first-class shape. Practically every mail-order outfit offers a variety of plastic bags full of diodes, capacitors, resistors, potentiometers, transistors, ICs, and other small components.

A few words of caution apply. Buying these goodies is of use only if you are building up a spare parts inventory, not to yield components for a specific project. Rarely will you come out with just what you need from a grab-bag. Carefully check the description of what's in the bag. For example, are the components assorted popular values, or are they all of one unusual (and possibly unusable) value? Are the leads cut too short, good for use in PC board wiring only? To what tolerance are the component values? And, are the components new, used, or seconds?

For the beginners, assortments of hardware, hook-up wire, small switches, knobs, low-wattage carbon resistors, ceramic disc and polystyrene capacitors, high-capacitance, low-voltage electrolytic or tantalum capacitors, popular transistors and common ICs, carbon potentiometers, and small transformers are good for starters.

A $15 or $20 investment in plastic bag components, if the choices are made wisely, represents money well spent. Realize that there isn't much recourse for a bad selection. You take what you get and chalk up the results to experience. It's a good idea to check out plastic bag components for proper value, shorts, open circuits, and physical damage before using them in construction projects.

component identification

Most direct-mail firms carefully label and package components they ship so that you will have little problem in identifying the parts you receive. General-

ly speaking, ICs are labeled, transistors stenciled or mounted on labeled cardboard sheets, capacitors imprinted with their values, resistors and transformer leads color coded, and so on. Exceptions are diodes and some bulk-sale components, especially ICs, coils, and capacitors, which may not be labeled. These present real problems in component identification for all but the most knowledgeable experimenter. Special color codes exist for some diodes, however, and capacitor and coil values can be measured. But determining IC and transistor types can be sporty, to say the least. Buying surplus PC boards is risky, too. Identifying and safely removing the components is sometimes a real challenge. Most resistors and capacitors are prominently color-coded for easy identification.

Coding and values for other components, such as hookup wire, transformers, pilot lamps, and diodes can be found in the ARRL *Handbook* and the Editors and Engineers *Radio Handbook*, as well as in other radio-electronic reference books. Identifying the values of unknown/unmarked components, like capacitors, coils, and chokes is an art unto itself. However, ARRL's *LCF Lightning Calculator* provides the data needed to make many tricky identifications, when used in conjunction with a grid-dip oscillator or other rf source.

closing remarks

We've only scratched the surface. But you should have a good idea of the facts to consider when lining up parts for your next construction project.

Buying parts by mail-order can be a money-saving and interesting way to help complete your electronic projects. Provided you recognize the rules of the game, direct-mail buying can even be fun. Give it a try!

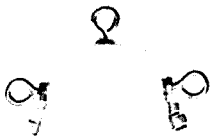
ham radio

did anyone hear Amelia?

For the last several years, Paul L. Briand, Jr., Professor of English at the State University of New York at Oswego, has been conducting research into the disappearance of Amelia Earhart in 1937. Amelia Earhart, the first woman to fly the Atlantic, was last heard from while crossing the Pacific on the final leg of an around-the-world flight. Any shortwave listeners who might have heard her transmissions in early July of 1937 (her call letters were KHAQQ) are asked to contact Dr. Briand, Department of English, SUNY College, Oswego, New York 13126 (telephone 315-343-0635).

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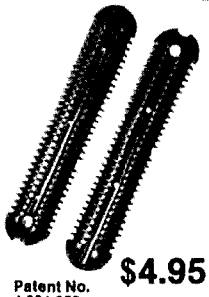
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D-20	20	33'	24.95	20.95
D-15	15	22'	23.95	19.95
D-10	10	16'	22.95	18.95
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SD-80	80/75	90'	31.95	27.95
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PD-4010	40,20,10/15	66'	33.95	29.95
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10-meter preamp for the FT-101E

Easy mods for improving the sensitivity of this popular radio — and others as well

This article does not provide construction details for a preamplifier; rather it describes how to install a preamplifier in an FT-101 transceiver. The preamp chosen by the author was described in the March, 1979, issue of *QST* by Doug DeMaw, W1FB. If you don't wish to use the referenced amplifier, others are available in kit form. Some examples are the Hal-Tronix HAL-PA-19 or the Hamtronics P-30. Editor

During a 1979 10-meter contest, my station was operated for the first time in the full-power, multi-operator category. My partners in this effort were KA1BMB, WA1YEC, and WB1GIF. Before the contest began, we felt that all was in readiness, having set up the amplifier and antenna in plenty of time (that afternoon). The first hint of trouble came about an hour into the test when we calculated our less-than-astonishing rate of 25 QSO's per hour. Maybe it's the band? The second hint was the phone calls that started coming in, asking why we were calling CQ over the JAs, etc., who were *calling us*. One-way propagation?

The real problem, of course, turned out to be the rather poor 10-meter sensitivity of my FT-101E. After talking with other FT-101 owners, I found this to be a relatively common problem in an otherwise well-engineered transceiver.

design considerations

A preamplifier seemed to be the logical remedy for

By Dave Malley, K1NYK, 132 Lydall Street, Manchester, Connecticut 06040

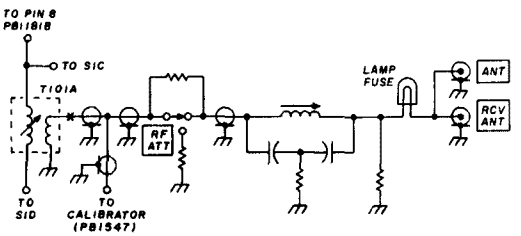


fig. 1. FT-101 circuit before adding preamp showing the location (X) selected for its installation.

the problem of poor sensitivity. Since I enjoy homebrewing, I decided to build the preamp and set about to find an existing design that met the following goals:

1. Stable (no self-oscillations)
2. 1-MHz bandwidth or better
3. Good gain (15-20 dB)
4. Inboard installation
5. No loss of resale value (no hole drilling)

The advantages of the design criteria are readily apparent. In a broad sense, the circuit should bring a weak signal up to a solid Q5 copy without retuning when switching between the phone and CW subbands. Retaining the resale value meant not drilling holes for cables or switches, as well as minimizing circuit mods to the transceiver. The internal installation requirement simplifies portable/mobile operation and keeps the station from being cluttered with yet another black box and its various wires. A method of switching the preamp into the circuit without using rf relays was also desired.

I reviewed several construction articles to become familiar with the circuit options before making a selection. The design I selected[1] was simple, and all the goals were met. This preamp also can be set up for 15 meters instead of 10 meters if two toroid windings are changed.

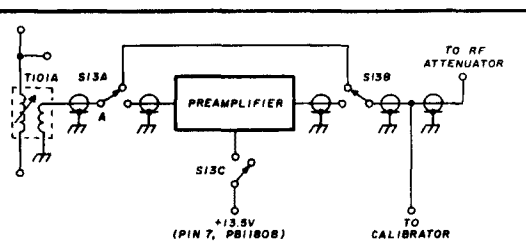


fig. 2. FT-101 circuit after modificaton showing added control switch and preamp module. Calibrator can be placed at point A, which may be more desirable (see text).

The contest was still on my mind, though, so I decided to stick with the 10-meter version. Construction is uncomplicated using a homemade circuit board, I found parts *in* my junkbox (oops, I mean my electronic inventory) — proving that no unusual components are needed. However, if all the parts are purchased, the bill will come to only around $8. This works out to about half a buck per decibel. If you're not inclined toward building this unit, a satisfactory commercial preamp can probably be found that will fit in the rig. Check the ads.

The first step should be to align both the receiver and transmitter 10-meter front-end sections. The FT-101 owner's manual covers this trimmer capacitor peaking procedure quite well. This procedure ensures maximum performance on 10, as would be expected.

As mentioned earlier, I hoped to avoid hold drilling and other mechanical (or major electronic) surgery. I wanted to be able to restore the transceiver to its original state.

After removing the bottom cover, I quickly found that the preamp board should be installed topside. The most space above the chassis is directly in front of the PA cage. As luck would have it, the 1.7 inch × 3.9 inch (43 × 99 mm) dimensions of my board allow it to fit vertically in this spot without interfering with the top cover. To avoid relays, which probably wouldn't fit inside the rig anyway, the preamp should be installed in the FT-101's receiver section.

A review of the circuit diagram showed that this could be done between the lamp fuse (rf overload protector) and T101A, (see fig. 1). The modified circuit diagram is shown in **fig. 2**. A 4PDT miniature toggle switch places the preamp into the circuit and simultaneously applies the 12-14 volts. Operation on all bands is not affected when the switch is off.

hardware and wiring details

A bracket was formed from a 3/4-inch-wide (19-mm) piece of 1/32-inch (1-mm) aluminum, which serves double duty by holding both the preamplifier circuit board and the miniature switch in position (**fig. 3**). The dimension marked with an asterisk should not be exceeded, or the top cover will not close properly.

Switch wiring is shown in fig. 4. RG-174 miniature coax was used for each rf run, and all coax braids must be grounded at each end. The circuit board and

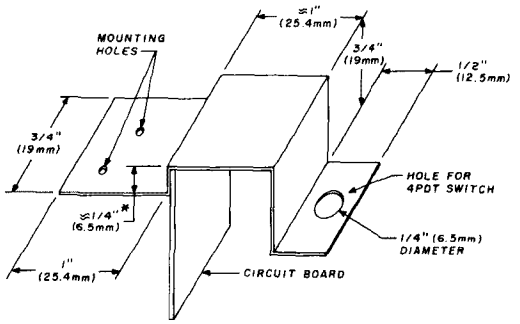


fig. 3. Sketch of the bracket used to mount preamp and switch assembly in the FT-101. The 1/4-inch (6.5-mm) dimension (asterisk) should not be exceeded (see text). Bracket attached to perforated PA cover, thus no holes need to be drilled.

the switch should be mounted on the bracket, then wired for greatest convenience. The cables that connect to the rig should also be soldered to the switch at this point. One or two short machine screws will ultimately secure the bracket assembly to an existing hole in the perforated PA cage cover. Make sure that these screws *do not* touch any components inside the PA compartment! This bracket arrangement provides very good mechanical stability.

The input/output lines from the preamp switches were passed around the driver tube socket and down through the opening beneath the heterodyne crystal oscillator board (PB1073), located in the right-front corner of the transceiver. Routing the coax cables around the tube socket is not necessary but gives enough slack to allow removing the board for adjustment or repair without unsoldering it.

The supply voltage wiring was routed from the switch through the opening under the VFO assembly and along to pin 7 of the mixer board socket (PB1180). I used a piece of scrap RG-174 for this

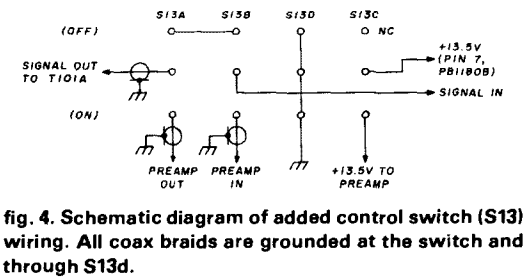


fig. 4. Schematic diagram of added control switch (S13) wiring. All coax braids are grounded at the switch and through S13d.

cable, too, and pin 6 or 8 of the PB1180 socket can be used for grounding the braid. Passing the wiring between the chassis underside and the speaker plate gives the neatest appearance. Although each FT-101 circuit board has one or more 13.5-volt connections, the mixer socket seemed to offer the easiest access point.

FT-101 circuit considerations

The simplest location for splicing the preamp into the FT-101 was right at the secondary of T101A, where the incoming signal is applied. The circuit board containing the front-end alignment trimmers must be temporarily moved aside to allow access to the T101A connections, which are between it and the underside of the chassis. Removing the wrap-around cover also is convenient.

T101A has five terminals, with three of them on the transformer secondary. One secondary terminal is grounded, while another connects to the incoming signal and the crystal-calibrator signal. In my radio, the red wire carries the incoming signal, and the yellow wire goes to pin 16 of PB1547. It would be wise to check these wires in your radio with an ohmmeter to make sure that no production changes have occurred. The middle terminal is not connected to T101A and serves as a convenient tie point.

Remove the incoming and calibrator signal wires from their existing transformer terminal. Attach them and the preamp input to the T101A middle (dummy) terminal. Now connect the preamplifier output coax cable to the terminal that originally held the incoming and calibrator wires. Both preamp input/output coax shields are grounded at, or adjacent to, the transformer ground terminal. Note that the calibrator wire can remain in its original location. Once this work is finished, be sure to replace the circuit board containing the front-end alignment trimmers that was moved aside earlier.

alignment

Alignment of the preamp *I selected* involved peaking two trimmer capacitors on the preamp board. This condition is registered on the S-meter using a signal generator loosely coupled to the FT-101's antenna terminal. I aligned the preamp before the bracket assembly was attached to the PA compartment cover then later tweaked the caps after final assembly. (This step may not be necessary if the caps are properly peaked initially.)

It's important to couple the signal generator very loosely to the rig without developing AGC voltage (no S-meter reading). Using the calibrator signal was unsatisfactory because it was too strong and masked the correct adjustments. This resulted in *no* amplification of the weak signals. After all, making the

weak signals stronger is the whole ball of wax! This unit works well and has no self-oscillations, body capacitive coupling, or other problems that can occur when LC circuits are not in resonance.

a final word

That completes the rig modifications, and the cabinet can be put back together. The photograph shows the circuit board and switch assembly installed beside the PA compartment. When the preamp is switched off, the receiver should work normally on all bands as before. My unit pushes a barely audible station to an S5-S8. While the no-signal noise is also amplified, this noise does not register on the S-meter, which indicates an overall increase in the signal-to-noise ratio. I found a minor secondary advantage of this modification with the rf-gain pot. Previously, a signal would disappear altogether when the rf gain was set below about 6. This pot now provides variable attenuation throughout its entire range when the preamplifier is turned on.

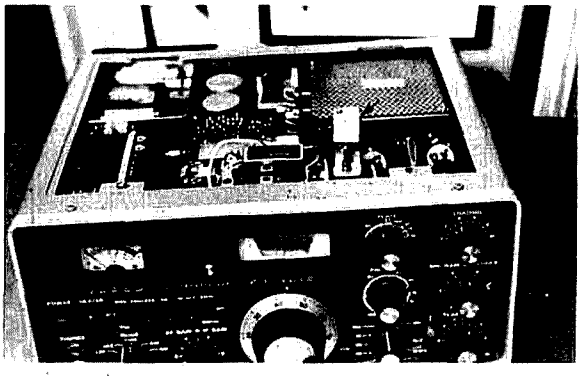


fig. 5. Photo of the preamp and switch assembled inside the FT-101 (arrows). Routing of the miniature coax cables is not critical and uses existing pass-through holes in the chassis.

While the mods discussed in this article are directed toward the FT-101, the same philosophies should apply to many other transceivers and receivers as well. This mod is quite effective. Having it integrated into the transceiver's circuitry certainly helps keep the station more orderly. Looking to the future, I expect this unit will be most beneficial as 10-meter propagation declines.

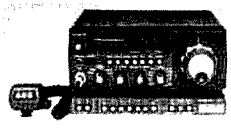
reference

1. Doug DeMaw, W1FB, JFET "Soup" for Tired Receivers, *QST*, March, 1979, page 19.

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A survey of antenna tuners — how QST and Lew McCoy, W1ICP, pioneered the "Transmatch"

ham radio TECHNIQUES

Bill Orr W6SAI

Society seems to go through a progression of fads. Senior citizens well remember when miniature golf courses, "Amos 'n' Andy," and the snood were all the rage in the thirties and forties. Most of us can name some post-war fads: the hula hoop, tail fins on autos, and hot tubs.

Amateur Radio, being in some ways a mirror of society, also has its fads. Old timers remember from pre-war times the Astatic D-104 microphone, the RME-69 receiver, preselectors, and the Johnson-Q antenna. In vogue today are keyboards and RTTY, quad antennas, speech processors, SWR meters, baluns, and antenna tuners. Time will tell which of these technological developments will be of the greatest benefit to Radio Amateurs.

This brings me in a roundabout way to the subject of this column: antenna tuners. If you look in the various ham magazines, you'll see a bunch of advertisements featuring antenna tuners. Everybody has gotten in on the act! You can even buy an antenna tuner to match the decor of your equipment. Obviously, you've got to have an antenna tuner to be a part of the action.

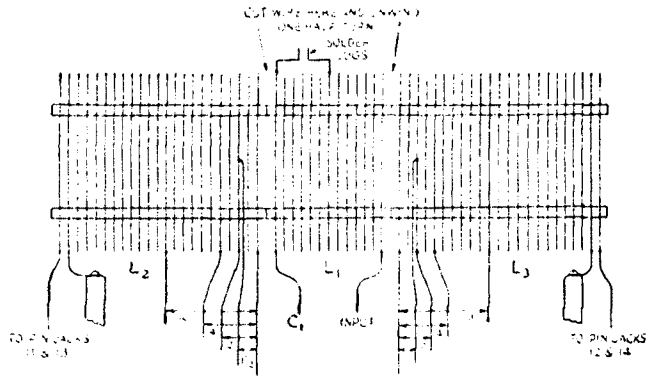
antenna tuner? what's that?

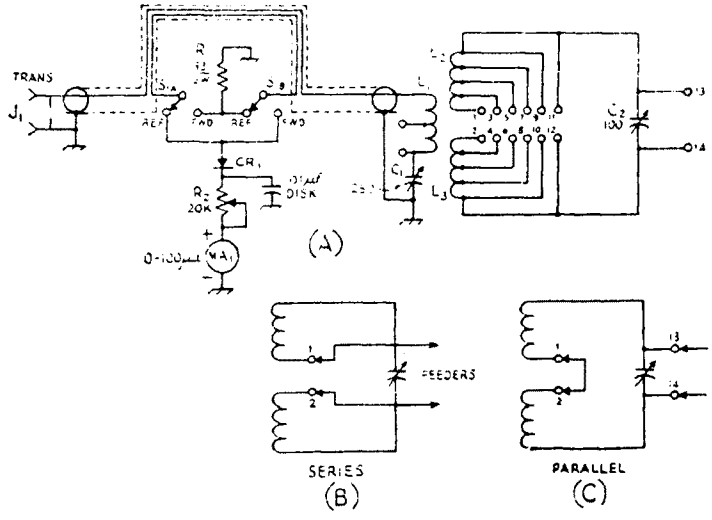
The term *antenna tuner*, as By Goodman, W1DX, once pointed out, is a misnomer. *It doesn't tune the antenna*. Rather, it's a matching device that translates the electrical characteristics of the antenna system into values more compatible with the communications equipment attached to the antenna.

Back in the days of open-wire feedlines and simple antennas, the antenna tuner was a resonant circuit coupled to the transmitter. A few copper alligator clips on the tuner coils permitted the operator to make loading adjustments to his taste. He didn't worry about the standing wave ratio (SWR) on the feedline — these magic initials were unknown to most Amateurs.

The SWR meter. With the availability of good, inexpensive coaxial cable after World War II, the switch-over from open-wire lines was inevitable. At about that time, Amateur Radio was introduced to the SWR meter. And the Federal Communications Commission introduced the Novice license, which brought a large number of new Amateurs on the air.

The influx of new, inexperienced hams on 80 and 40 meters brought a blizzard of problems for the FCC and *Amateur* Radio. The beginner's transmitter was unsophisticated and, more often that not, a prolific generator of strong harmonic signals. Moreover Amateur Radio as a whole was plagued with serious television interference (TVI) problems. Many





(A) Circuit diagram of the antenna coupler and s.w.r. bridge. (B) Series tuning. (C) Parallel tuning.

C1—250-μμf. variable capacitor (Hammarlund MC-250-M).
C2—100-μμf. variable capacitor (Hammarlund MC-100-SX).
CR1—1N34A germanium diode.
J1—Coaxial chassis receptacle, SO-239.
L1, L2, L3—See Fig. 2 and text.
MA1—0-100 microammeter, or other range, depending on sensitivity required.
R1—33 ohms, ½-watt carbon resistor.
R2—20,000-ohm potentiometer.
S1—D.p.d.t. "tone control" switch (Centralab 1462).

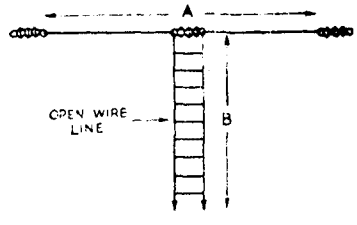
fig. 1. The antenna-tuner design that started it all. Shown in the March, 1959, issue of *QST*, this design brought the antenna tuner out of the dark ages. It incorporated a simple SWR bridge made from a length of coaxial line and a link-coupled circuit that could be adjusted for either series or parallel tuning of an open-wire transmission line. The air-wound coil is about 2 inches in diameter, 10 turns per inch. (Drawings from *QST*, March, 1959.)

Tuning Information

Parallel	*Series*
Connect feeders to 13 and 14, jumper 1 and 2	Connect feeders to 1 and 2

Short following terminals with jumpers

3.5 Mc.	— —
7.0 Mc.	11 and 9 — 12 and 10
14.0 Mc.	11 and 7 — 12 and 8
21.0 Mc.	11 and 5 — 12 and 6
28.0 Mc.	11 and 3 — 12 and 4



The length *A* should be more than a quarter wavelength at the lowest operating frequency. When you determine the length of *A* to half the distance, add a sufficient length of feed line (B) to equal a quarter wavelength or multiple thereof. For example, let's assume you can put up an antenna 80 feet long and you plan to operate on the 3.7-Mc. Novice band as the lowest frequency. From the formula

$$\frac{245}{3.7} = 66.5 \text{ feet}$$

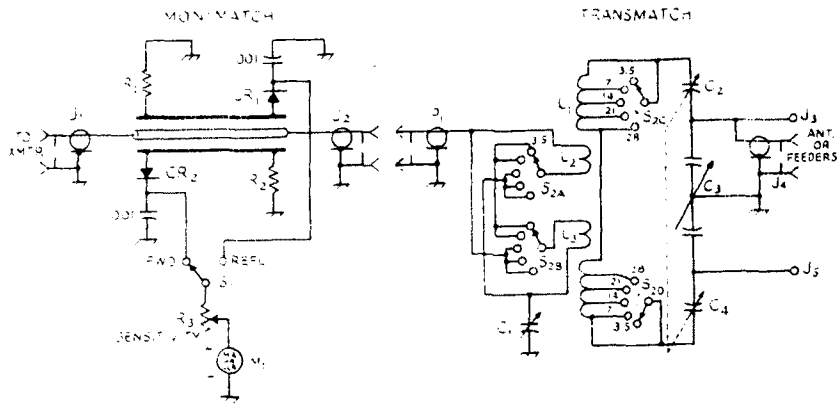
$$66.5 - 40 = 26.5 \text{ feet}$$

the feeder length, or

$$2 \times 66.5 = 133$$

$$133 - 40 = 93 \text{ feet.}$$

This can be carried out for greater feeder lengths, depending on the requirements of the installation.



Circuit diagram of the transmatch and Monimatch.

C —250-μμf. variable, 0.045-inch spacing for high power (Johnson 250E20); 0.025-inch spacing for low power (Hammarlund MC-250-M).

C_2, C_4—100-μμf. variable, 0.125-inch spacing for high power (Johnson 100E45); 0.025-inch spacing for low power (Hammarlund MC-100-M).

C_3—100-μμf.-per-section, dual variable, 0.125-inch spacing for high power (Johnson 100ED45); 0.025-inch spacing for low power (Hammarlund MCD-100-M).

CR, CR_2—1N34A germanium diodes.

J_1, J_2, J_3—Chassis-type coax receptacles, type SO-239

J_4, J_5—Feed-through insulators.

L_1, L_2, L_3—See Fig. 2 and text.

M_1—0–1 ma. or less; see text.

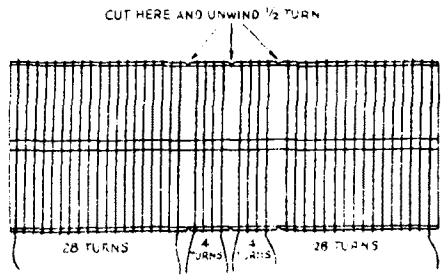
P_1—Coax plug, type PL-259.

R_1, R_2—For 50-ohm bridge, 150 ohms, ½-watt composition; for 70-ohm bridge, 100 ohms, ½-watt composition.

R_3—20,000-ohm control, linear taper.

S —Rotary, 1 pole, 2 positions (Centralab type 1460).

S_2—Ceramic rotary, 4 poles, 5 positions, 1 pole per section, 4 sections (Centralab index type P-122 with type "T" or "X" sections).



This drawing shows how to make the coil assembly. Not shown are the taps needed for changing bands. The tap points listed below all are counted from the outside ends of the coil.

7 Mc.—12 turns.
14 Mc.—23 turns.
21 Mc.—25 turns.
28 Mc.—26 turns.
The coil stock is 3 inches in diam., No. 14, 8 turns per inch

fig. 2. The 1961 version of the Transmatch. The SWR bridge is shown at left. The coils are tapped, and a rotary switch is used to select the proper inductance. Note that a coaxial plug (J4) has been added to the output terminations of the tuned circuit. Only one-half of the tuner circuit is used for the coaxial connection. (Drawings from *QST*, November, 1961.)

Amateurs thought that perhaps the old-fashioned antenna tuner might solve these problems. How could the old-design tuner be adapted from open-wire line to coaxial line?

The antenna tuner and SWR bridge circuit. Several solutions to this problem were introduced during the 1950s, but the most popular and effective tuner was that developed by Lew McCoy, W1ICP, the Novice Editor and Technical Assistant for *QST* magazine. An early version of Lew's device is shown in **fig. 1.** This tuner adapts a medium-power transmitter having a 50-ohm coaxial antenna output to a center-fed, all-band antenna. A simple SWR meter is incorporated into the tuner. Small copper clips make connections to the tuner coil as the band is changed. This is a prac-

tical all-band (80- through-10-meter) antenna and tuner, and I recommend it to any Amateur looking for a versatile, simple, and inexpensive antenna system. For more details, refer to the March, 1959, issue of *QST*, pages 11-15.

Later, in the November, 1961 *QST* Lew showed a high-power (500-watt) version of his tuner — a deluxe model having a wider adjustment range — and he called it a Transmatch. Again, it was designed to match a 50-ohm coaxial antenna output to an antenna having a balanced feed system. But he also added a coaxial output plug to the Transmatch to match to a 50-ohm transmission system. In this manner, the Transmatch could be used as a highly selective circuit in a 50-ohm coaxial system that would greatly attenuate the harmonics of the transmitter. The circuit is shown in **fig. 2**.

By 1966 the impetus had switched to harmonic suppression on 50-ohm transmission lines; so the October, 1966, issue of *QST* featured a simplified McCoy Transmatch that eliminated the SWR meter and emphasized single-ended output (**fig. 3**).

In 1967 an entirely different approach to an "antenna tuner" was described by Lance Johnson, K1MET. He built a simplified, single-ended tuner based upon a T-section network that provided an unbalanced-to-balanced match for a 50-ohm transmission system (**fig. 4**). This compact and simple Transmatch is an excellent solution to some of today's problems with solid-state rigs: it will reduce the SWR on an antenna system to near unity, so that the transmitter does not suffer reduced power output caused by operation into a mismatched load.

the "Line Flattener"

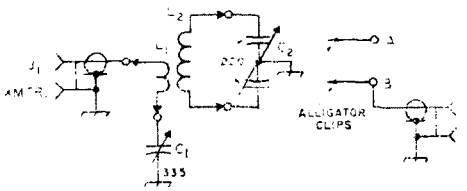
This circuit has shown up in Radio Amateur literature numerous times since its first introduction by K1MET (then an ARRL Lab Assistant). Previously, it had been in wide commercial use but somehow had never filtered into ham literature. In addition to providing a good match, the T section (**fig. 4**) provided up to 20 dB attenuation for transmitter harmonics falling into the TV channels. An extremely practical circuit, this low-cost device is recommended to today's Amateurs who have solid-state transmitters and who wish to achieve easy and efficient antenna matching with a minimum of fuss.

By now the name Transmatch was slipping into the public domain, and almost every "antenna tuner" was called a Transmatch. (Too bad, Lew. You've suffered the fate and fame of Kodak™ and Xerox™!)

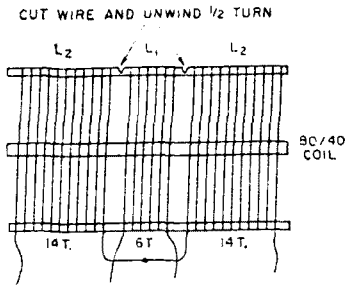
A simplified Line Flattener for a tri-band beam (10-15-20 meters) can be built. Capacitor C1 is reduced to 250 pF, capacitor C2 is removed, and the end of coil L2 is connected directly to receptacle J2 (**fig. 4**). Then, coils L1 and L2 are reduced to nine turns each. Readers with a good memory will recall that I described a compact, 100-watt version of the Line Flattener in my antenna column in *CQ*, April, 1979. A somewhat similar device was also described by W6EBY in the September, 1978, issue of *ham radio* (page 22).

back to the Transmatch

By 1961 the antenna tuner had taken an interesting turn, and an article describing the "50-Ohmer" by Lew McCoy appeared in the July, 1961, issue of *QST* (**fig. 5**). This device was a form of Line Flattener designed to be used with a coaxial system to reduce the SWR on the

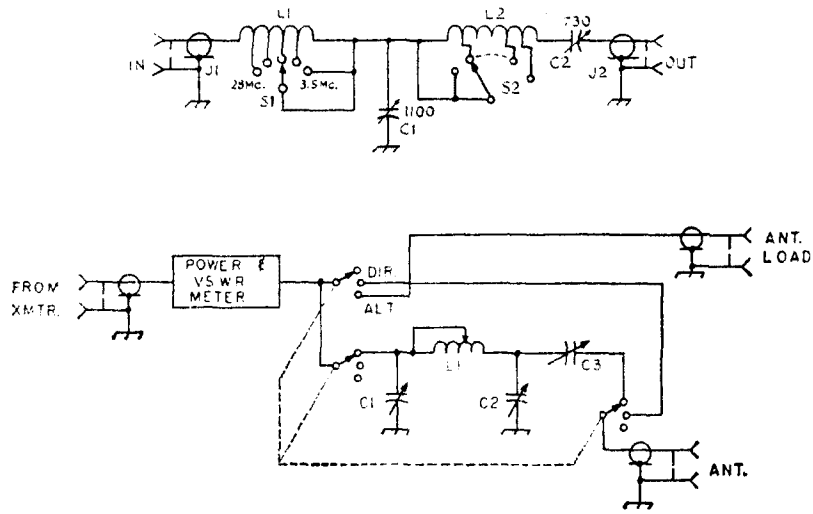


Circuit diagram of the transmatch. Balanced feeders should be attached to A and B.
C_1—335 pf. variable (Millen 19335 or equivalent).
C_2—200 pf. dual variable, 0.077-inch air gap for 1 k.w. (Millen 16200), 0.022-inch air gap for 150 watts and less (Millen 28200).
J_1, J_2—Coax chassis fitting, SO-239.
L_1, L_2—See Fig. 3 and text.



Details for making the 80/40-meter coil. The 20-meter coil consists of 2 turns for L_1 and 6 turns for L_2 (3 turns on either side of L_1). Details for the 15/10-meter coil are given in the text. The coils are mounted on Millen type 40305 plugs and the socket is Millen type 41305. Coil stock is Polyphase PIC type 1778, 3-inch diameter, 6 turns per inch, No. 12 solid wire.

fig. 3. The tuned-circuit antenna-matching device reduced to the simplest form. The SWR meter is eliminated, but provision for 50-ohm coaxial output is included. (Drawings from October, 1966, *QST*.)



Circuit of the 300-watt transmatch. Capacitances are in pf. For simplicity, only a few of the taps on L_2 are shown.

C_1—365-pf. variable, 3-section, receiving t.r.f. type (Miller 2113 or equivalent).
C_2—365-pf. variable, 2-section, receiving t.r.f. type (Miller 2112 or equivalent).
J_1, J_2—Coax chassis fitting, SO-239.
L_1—13 turns No. 14, 1¾-inch diam., 8 turns per inch, tapped at 3, 5, 9, 11 and 12 turns from J_1 end (Polycoil 1764 or equivalent).
L_2—21 turns same coil stock as L_1, tapped every other turn.
S_1—Ceramic rotary, 1 section, 1 pole, 2-6 positions (Centralab PA 2003 or equivalent).
S_2—Ceramic rotary, 1 section, 1 pole, 2-11 positions (Centralab P-270 index & YD section or equivalent).

fig. 4. The 1966 Transmatch (top). This is a T-section network that provides a match within a 50-ohm transmission line system. The configuration is well suited to today's solid-state equipment. Tuner is designed to cover 160 through 10 meters. A pi-network circuit, below, is used in the Drake MN-4 matching network. (*Drawings from QST, October, 1967.*)

transmission line. It used a "band-switching adjustable transformer" capable of handling SWR values as high as 5 to 1. Of interest to the circuit connoisseur is the use of a split-stator tuning capacitor with network input attached to the floating rotor.

This shunt provided a capacitive short circuit to ground for the transmitter harmonics and gave protection up to 20 dB for harmonics falling into the TV channels — a slightly different version of the K1MET design.

the Ultimate Transmatch

In July, 1970, W1ICP came up with the Ultimate Transmatch in his "Beginner and Novice" column of *QST*. This circuit was a sophisticated version of the 50-Ohmer, adapted for either coaxial lines or balanced lines. A 1-to-4 ferrite balun was used to achieve balanced output (fig. 6). This Transmatch combined simplicity and flexibility, requiring only one split-stator capacitor, one single-section capacitor, and one variable inductor. Many of the antenna couplers sold today employ this circuit or variations of it. The output termination for the balanced configuration is 200 ohms when the input to the Transmatch is 50 ohms.

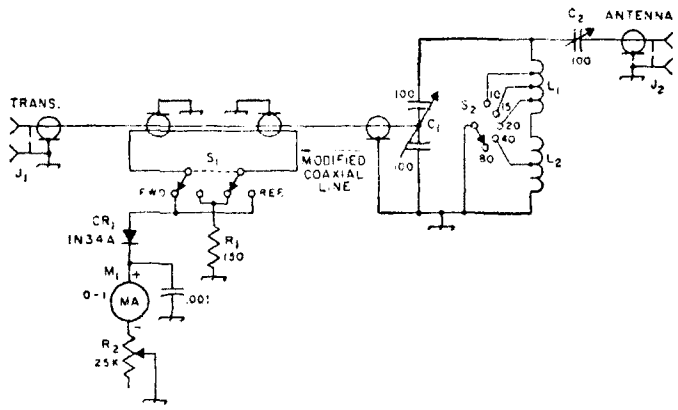
The use of a ferrite balun, however, should be approached with caution. Most balanced lines are other than 200 ohms (300 ohms for TV ribbon line, and 450-600 ohms for open-wire transmission line). Ferrite baluns don't like to work into a mismatch because of core saturation. The result of this misuse is increased harmonic radiation and the chance of balun flashover at medium power levels. An air-core balun at this point is recommended.

the SPC Transmatch

Shown in the 1981 *ARRL Handbook* is the SPC Transmatch (SPC standing for series-parallel-capacitance) — another offspring of the long series of antenna matching units pioneered by W1ICP and others. A simplified schematic of the *ARRL Handbook* version is shown in fig. 7. This unit was developed by Doug DeMaw, W1FB. It provides a wide range of matching and gets around the ferrite-core balun problem by substituting an air-core device.

which antenna tuner to build or buy?

So much for the background of the Transmatch, now firmly established as part of the history of Amateur Radio. Much information is available for the interested Amateur who



Circuit diagram of the 50-Ohmer. Decimal values of capacitances are in μf., others are in μμf.

C_1—100-μμf.-per-section, split stator (Hammarlund HFBD-100-C).
C_2—100-μμf. variable (Hammarlund MC-100-SX or Johnson 100 FD 20H).
CR_1—1N34A germanium diode.
J_1, J_2—Coax chassis terminal, SO-239.
L_1—9¾ turns No. 14, 1¾-inch diam., 4 turns per inch (B & W Miniductor 3021, Illumitronic Air Dux 1404T). 14-Mc. tap 2½ turns from junction of L_1L_2; 21-Mc. tap 7½ turns from junction of L_1L_2; 28-Mc. tap 7½ turns from junction of L_1L_2.
L_2—28 turns No. 14, 1¾-inch diam., 8 turns per inch (B & W Miniductor 3022, Illumitronic Air Dux 1408T). 7-Mc. tap 5 turns from the junction of L_1L_2.
M_1—0–1 milliammeter.
R_1—150 ohms, ½ watt.
R_2—25,000-ohm control, linear taper.
S_1—2-pole, 2-position switch (Centralab 1462).
S_2—Ceramic rotary, one section, one pole, 5 positions (Centralab type 2501).

fig. 5. The 50-Ohmer circuit of 1961 is the forerunner of today's Transmatch. The split-stator capacitor C1 provides good rejection of the transmitter harmonics and provides TVI protection when it is properly adjusted. Note that high-impedance output for two-wire transmission line has been dropped. (*Drawing from July, 1961 QST.*)

wants to buy or build a Transmatch. As to the question, "Which antenna tuner should I build or buy?," the first answer is, Don't use an antenna tuner unless you really need it. Too many Amateurs are swept away by antenna tuner fever when they could just as well get along without one.*

Where the Transmatch really shines is in conjunction with a solid-state transmitter and, say, a triband antenna. The tribander provides various terminating impedances as operation is conducted across the bands, and sometimes the solid-state transmitters encounter loading problems, especially at the band edges. The Transmatch will transform the odd-ball impedance at the station end of the transmission line into 50 ohms, which is what you would want for a good match to the transmitter.

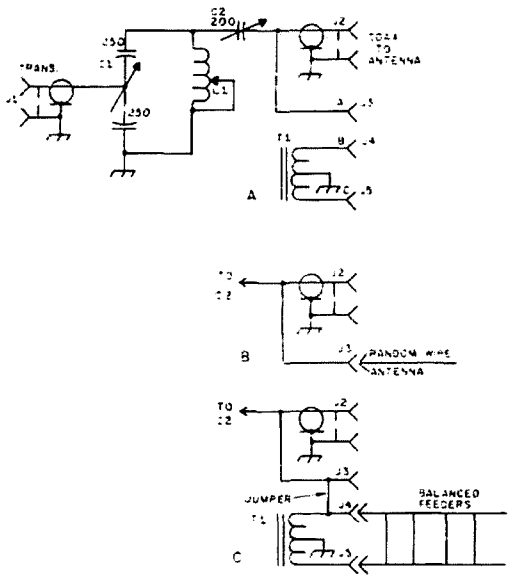
The transmitter employing vacuum tubes and a pi-network output circuit is considerably more tolerant of a high SWR antenna load, and in most cases a Transmatch is not required to match a 50-ohm line to the transmitter, with one exception: 80 meters. The great majority of 80-meter ham antennas cannot work across the whole band without exhibiting a high value of SWR at one end of the band or the other. And here is where a Transmatch is worthwhile. Even though the antenna may be operated "off tune" and may exhibit a high SWR on the feedline, the Transmatch can provide a satisfactory load for the transmitter.

Which model Transmatch to build or buy? I'm not going to get into a dispute over that. My Transmatch needs are modest, so I have a haywire version of the T-section device shown in **fig. 4**. In fact, I have two of them. One is built up very pretty in a low-profile case, complete with SWR meter and all bells and whistles. The other one is built upon a small sheet of plywood, and the components are interconnected with flexible leads and copper-plated battery clips. It is very flexible and I can rearrange the circuit at a moment's notice to fit the need at hand.

If I were buying a Transmatch I would want to look inside the pretty case and examine the innards. Is a good quality ceramic switch used? Do the capacitors have sufficient plate spacing for the power level indicated? Are all rf connections well made — solid and firm? Is there sufficient air space around the inductor so that the metal cabinet is not inductively coupled to the coil, producing an unwanted shorted turn in the metal of the box? Sometimes a

*However the antenna matching unit does attenuate harmonics. Editor

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Circuit diagram of the Ultimate Transmatch.
C1 – Split-stator variable, 250 pF per section; see text. For low-power version, E.F. Johnson type 16250; or similar, for high-power version, Millen type 16250, or similar.
C2 – 200-pF variable, for low power, E.F. Johnson type 167-12 or similar, for high power, Millen type 16520, .171-inch spacing, 16520A, .077-inch spacing, or similar.
J1, J2 – Coax chassis fitting, type SO-239.
J3,J4,J5 – Feed through insulators.
L1 – Roller inductor, see text. If 160-meter operation is desired, total inductance should be 28 uH, E.F. Johnson type 229-203; otherwise, 18 uH is adequate, E.F. Johnson type 229-202.
T1 – 1-to-4 balun; see text for details, cores are Amidon type T-200-2.

fig. 6. The Ultimate Transmatch of 1970. The split-stator circuit is used, and a ferrite-core balun has been added for balanced feeders. (*Drawing from QST, July, 1970, page 24.*)

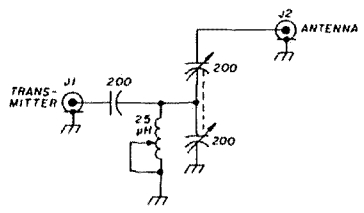


fig. 7. The SPC Transmatch shown in the 1981 *ARRL Handbook* is merely the Transmatch of W1ICP hooked up backwards! For balanced lines, an air-core balun is attached to antenna receptacle J2.

photograph of the interior of the tuner will give you these answers.

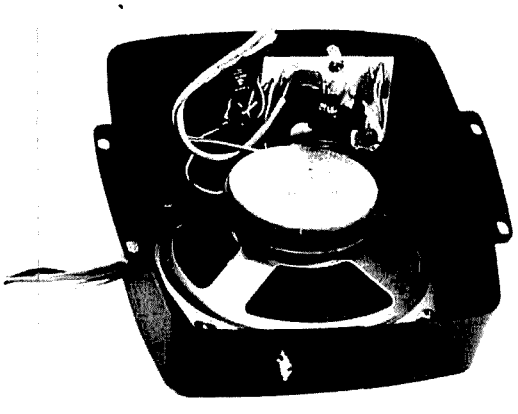
Note: A few months ago I offered readers of this magazine a reprint of my series of articles entitled "Design Considerations for Linear Amplifiers." This brochure has been reprinted and is again available. If you wish a copy, I'll be happy to send one to you for two 18-cent stamps (overseas readers send four IRCs). Write to me at EIMAC, 301 Industrial Way, San Carlos, California 94070 U.S.A.

ham radio

an audio amplifier
for your handheld transceiver

Build this convenience accessory and avoid freeway trauma

Today's handheld transceivers are marvelous little radios. A long list of optional accessories makes it possible to tailor them to many applications. However, most don't have sufficient audio output to be used in a car. It's not much fun to drive while trying to hold the radio and its speaker/microphone to your ear. So a simple audio amplifier, with sufficient output to be heard over any amount of road noise, is a useful accessory. Let's build one.



The audio amplifier is mounted inside the speaker enclosure using a metal stand-off post. The power and audio leads are secured with a plastic cable clamp.

the circuit

In fig. 1 an LM383 IC (U1) does all the work. It contains a preamplifier, power amplifier, and circuitry to protect against overheating, short circuits, and voltage spikes from an automotive electrical system. It operates from a 13.5-volt supply and can provide up to 5 watts of audio output. It delivers a gain of 100, about 40 dB.

Looking at fig. 1, R1 provides a load for the audio section of the handheld. (Some of the components used in the circuit prevent 2-meter energy from getting into the amplifier.) RFC1, C7, and C2 filter the input line, and RFC2 and C6 decouple the speaker lead.

The LM373 is a stable, well-behaved amplifier. R2 and R3 form a resistive divider, which provides negative feedback to pin 2 through C8. A key to stability is C4, which must be a metalized-fiim capacitor, with short leads, connected from pin 4 to pin 3 of U1. Other types of capacitors *should not* be substituted. Components used in the amplifier, except for the ferrite beads, are available from many local electronic-equipment suppliers. Ferrite beads are sold through mail order (check the ads).

By Douglas A. Blakeslee, N1RM, 4 Maple Lane, Brookfield, Connecticut 06804

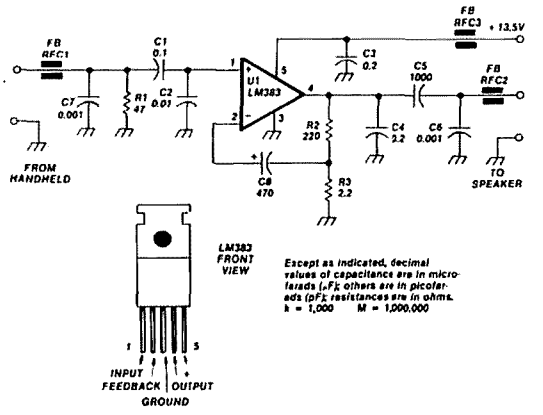


fig. 1. Schematic diagram of the audio amplifier. All capacitors are ceramic except C2, C3, and C4 (metalized film type) and those with polarity indicated, which are electrolytics. RFC1-RFC3 inclusive are jumbo ferrite-bead, VHF type, or three small VHF beads slipped over a short piece of hookup wire. U1 is a National Semiconductor audio-amplifier IC.

construction

The amplifier can be built using point-to-point wiring on a piece of perf board, on a universal circuit board, or on a homemade board, as shown in fig. 2. Whatever type of board you choose, follow the general component layout of fig. 3. If you use an etched circuit board, touch up the copper portion with some fine steel wool to remove any oxidation. Mount the components a few at a time, and bend the leads slightly to hold them in place. Solder all connections. Then inspect all solder joints to ensure they are bright and shiny. If a joint is dull and matted with solder, reheat it until the solder flows.

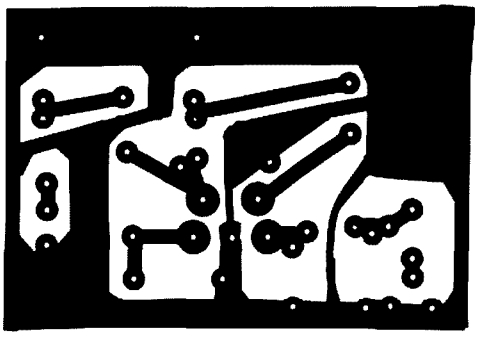


fig. 2. PC-board foil pattern for the audio amplifier.

To produce loud audio, a speaker must move air. Thus, a 2-inch diameter speaker isn't much good. A 4-inch diameter speaker is adequate, and 5- or 6-inch speakers are even better. I chose a 5-inch diameter speaker with housing, sold as an add-on rear-seat extension speaker. I mounted the audio amplifier inside the speaker housing (photo). If you use one of the extension speakers sold for CB radios and there is not enough room inside the speaker enclosure for the circuit, use a small aluminum box to house the amplifier.

power

The nominal 13.5 Vdc from an automotive electrical system is just what's needed for the audio amplifier. However, it's also desirable to power the handheld from the car electrical system, as rechargeable batteries are insufficient for long trips. Powering your handheld may not be so simple. Read your instruction book carefully. My FT-207 manual cautioned that the voltage applied be limited to 12 volts or below.

Inspection of the circuit diagram showed two dc input paths: one for needle-pin connections in a

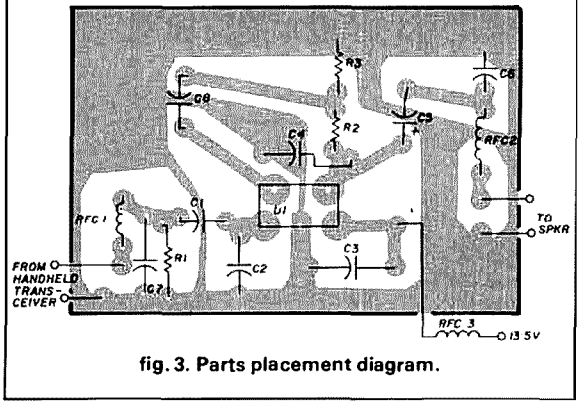


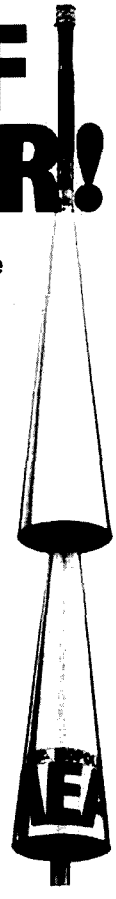
fig. 3. Parts placement diagram.

holder/power supply, and the other a jack for the battery charger. The circuit has one diode in series with the pin contacts and two diodes between the battery-charger jack and the set. (Silicon diodes typically have a voltage drop of 0.6 volt.)

Automotive electrical systems are noisy electrically and often have high-voltage spikes called transients. The lead-acid storage batteries used in cars have a nominal voltage of 12.6. Fully charged, the batteries will show a potential of approximately 13.5 volts. The battery-charging system delivers 14 volts or more. Transients of up to 300 volts are produced during normal operation of the car. This is not the sort of power source to be directly connected to a handheld

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radio designed to operate from a mild-mannered nicad battery!

I chose to use the charger input jack to power my radio. With a maximum of 14.5 volts from the car, the power circuit of **fig. 4** was used. The two diodes inside the FT-207 provided a 1.2-volt voltage drop. I used two additional diodes in series with the power lead, so that the maximum voltage applied to the radio would be 12.1 volts. I included a 15-volt zener diode to clip any voltage transients. Also, I used a capacitor to reduce the noise from the automotive electrical system. (In some installations, a more extensive filter may be needed to eliminate alternator whine.)

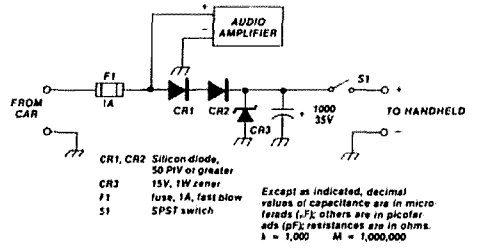


fig. 4. Schematic diagram of the power circuit.

installation

Installation details can be changed to suit individual requirements. My original goal was to use the radio for hamming while on family trips. I built the circuit of **fig. 4** into the speaker on a solder-lug strip. The power cord is equipped with a cigarette-lighter plug for instant installation.

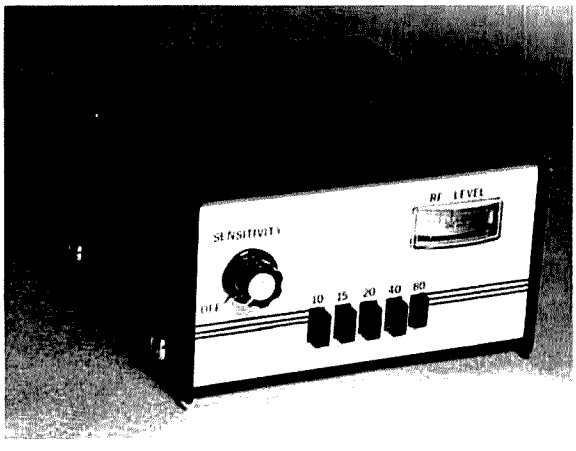
Two short cords with miniature phone jacks connect to the radio, one for power and one for audio. S1 of **fig. 4** ensures that power is off until the power cord to the radio is in place. (It's impossible to insert or remove a "hot" phone plug without hitting ground simultaneously, which results in an impressive flash and a blown fuse!)

If you want a semi-permanent installation, the speaker and amplifier can be mounted under the dash or at any other convenient spot. I place my radio beside me on the car seat when traveling and use the remote microphone. Volume and squelch controls are handy, and the band-search feature is useful for finding repeaters when in unfamiliar areas. Best of all, when I arrive at my destination, the radio can be disconnected in seconds and clipped to my belt.

ham radio

Printed-circuit techniques,
solid-state devices,
and some old-time technology —
a project for
the first-time builder

field-strength meter
for the high-frequency Amateur bands



Here's a project for the first-time builder — a band-switching field-strength meter. It's a neat accessory for your station that indicates the relative field strength of a signal. Actually, it's a small, band-switched receiver covering the Amateur 80, 40, 20, 15 and 10 meter bands. In this unit the speaker or headphones have been replaced by a meter that indicates the relative field strength. The receiver is a very basic unit, but it's sensitive enough for critical antenna adjustment and tuning. It's battery powered, allowing you to work at some distance

By Ken Powell, WB6AFT, 6949 Lenwood Way, San Jose, California 95120

from the antenna. And it's sensitive enough so that a short whip antenna, as used on 2-meter portables, will serve as a pickup or receiving antenna.

The field-strength meter is constructed on a single printed circuit (PC) board. Component count is low, overall cost is minimal, and the highest voltage encountered is only 3 volts. The field-strength meter has a minimum number of controls: a push-button bandswitch, an rf-level meter, and a sensitivity control that keeps the instrument within reasonable bounds as you get your antenna and transmitter really humming!

The complete unit is about 5 inches wide, 6 inches deep, and 3 inches high (13 × 15 × 8 cm). It could be squeezed down a bit smaller; but, in the interest of making construction a pleasure rather than a chore, the package was kept on the roomy side. Component values are not overly critical, and no special tools or equipment are required for construction or adjustment.

circuit

The description of the field-strength meter makes it sound a bit more complex than it really is. A glance at the schematic (**fig. 1**) shows the simplicity of the circuit. Band switching sounds complex because we tend to think of large rotary switches and the like; but in this case, band switching is handled by a simple push-button switch mounted on the PC board. This eliminates a lot of wiring and the chance for errors. This type of switch is a real boon to the builder.

The circuit is actually a crystal set, much like those used by the pioneers of early wireless. The antenna is connected to the primary of the rf coil, L1; the secondary of this coil is tapped to provide resonance on each of the high-frequency bands covered by the field-strength meter.

The push-button bandswitch, S1, selects the desired tap on the secondary winding of the coil, L1, and shunts the secondary tap with the required capacitance to provide resonance at each switch position. To make parts procurement easy, the same variable capacitor is used on each band and is shunted by a fixed capacitor where required (see **fig. 1**). This provides a trimmer for setting each band and eliminates the need for a front-panel tuning control.

The voltage developed across L1 is applied to the detector, CR1, a germanium diode. This rectified voltage is filtered by capacitor C10 and applied to the base of Q1. This general-purpose germanium NPN transistor is an amplifier. It allows the use of a low-cost meter movement as an output indicator. (The alternative is a more sensitive meter, which is more expensive and more subject to damage.) The meter is shunted by sensitivity control R1, which allows a selected portion of Q1's collector current to bypass the meter movement. This enables you to maintain the meter needle within a usable portion of the meter scale as varying signals are applied to the antenna terminal. The overall collector current of transistor Q1 is limited by resistor R2. The power OFF/ON switch, S2, is coupled to the sensitivity control. The wiring is such that the full clockwise rotation of the control yields maximum sensitivity.

Power for the field-strength meter is supplied by two AA cells mounted on the PC board. Current consumption of the unit is low: battery life should approximate the shelf life of the batteries. Trimmer capacitors C1 through C5 provide individual tuning for each of the bands, and once the unit is adjusted, it's not likely that any drift will be encountered.

construction

Construction of the field-strength meter is really tailored for the first-time builder, and the parts cost, even in today's wild economy, is low. Components aren't especially sensitive to rough handling, and the package is not crammed or difficult to assemble. Radio-frequency circuits are often difficult to duplicate, but printed-circuit construction *and* standard coil stock take care of that nicely.

Standard hand tools and a drill are all that are required for construction. The aluminum of the case is very soft, and woodworking tools handle it well. A bit of filing is required to get the rectangular holes for the band switch and meter movement, but it's really not much of a task.

let's get started

The first step in the construction of the field-strength meter is to obtain the components shown in **table 1**. The PC board should be etched and drilled in accordance with the foil layout depicted in **fig. 2**. If you don't have the facilities for fabricating the PC board, an etched and drilled board, complete with the bandswitch assembly installed, is available. The source for this board is shown in **table 1**.

To start construction, mount the bandswitch and solder it in place on the PC board. Next, mount the four spacers on the foil side of the PC board. These spacers elevate the board above the base of the cabinet.

Now, before mounting any other components on the PC board, take the time to work out the mechanical details of the PC board in relation to the cabinet. If you use the same case I did and want to have the same general layout on the front panel, see the layout in the photos of the completed unit.

The front panel will require five rectangular holes for the switch assembly, a rectangular hole for the meter, and a round hole for the sensitivity control.

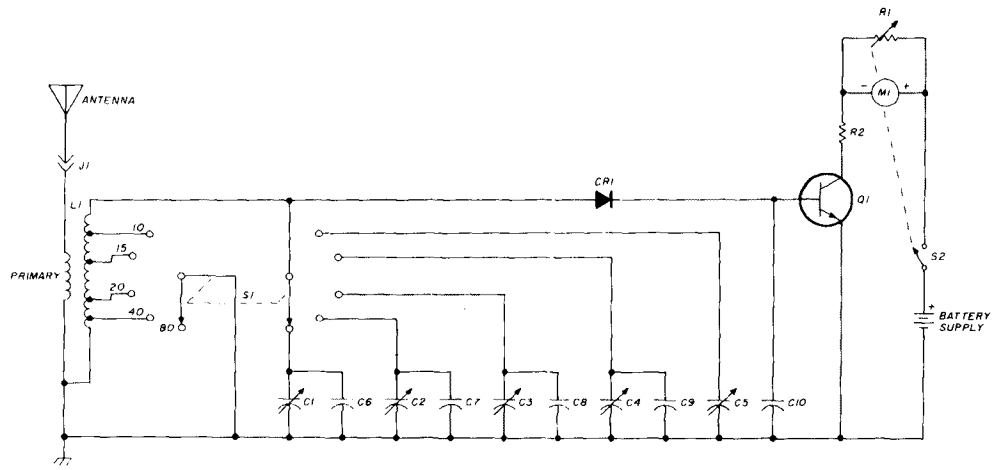


fig. 1. Schematic diagram of the bandswitching field-strength meter. Circuit is kept simple by using simple pushbutton switch mounted directly on the PC board.

The rear panel will require holes for the UHF connector used for the antenna.

After making the cutouts in the case, the PC board can be placed into the case, and the clearance for the push buttons can be checked. If things seem to fit well, mark and drill the four holes in the base for mounting the PC board and the rubber feet furnished with the case. When you're satisfied with the mechanical details, you can go on to complete the assembly of the board.

mounting small parts

The PC-board-mounted components, with the exception of rf coil L1, can now be mounted and soldered in place on the board as shown in **fig. 3.** When mounting components try to develop the habit of installing like components in the same direction so all values can be read from one side or edge of the PC board. In this case, all capacitors would be installed in the same direction. This is a good practice for all your projects and can make service and checkout easier.

Install the four wires that leave the board, using stranded wire to reduce the chance of wire breakage. Leave these leads about 6 inches (15 mm) long and trim them during the final stages of wiring. Color-coded wire is good for this purpose, and if you use color codes, note them on the schematic for reference. The PC board can now be set aside and work can be started on rf coil L1.

the rf coil

Before starting work on L1, study the drawing shown in **fig. 4.** Develop a fairly good idea in your mind of how the coil is to be formulated, as it is a very easy thing to get confused. Initially, the coil stock is 3 inches (76 mm) long and contains 48 turns held in place by four plastic formers.

Starting at the left end of the coil, as shown in **fig. 4,** count off four complete turns then go about one-third of a turn further, just past the second former, and cut the wire. Fold this wire back so it leaves the coil stock parallel to the lead at the start of the coil. This forms the four-turn primary of L1. The remaining end of the wire just cut will be the lead wire for the secondary and is peeled from the coil stock until it is parallel with the primary coil leads. This will leave a single-turn space between primary and secondary windings of L1. From this initial point on the secondary, count off 31 turns and again cut the wire about one-third way around the coil form. Fold this wire back parallel with the other coil leads. Remove the remaining coil stock and you should have a four-turn primary and a 31-turn secondary.

Now to put a few taps on the secondary. Using nail polish or other marking device, put a small mark at the fourth, seventh, ninth, and eighteenth turns of the secondary. These marks should be placed at the former, and the taps will be soldered just past the marks in the direction of the coil winding.

Scrape the coil plating lightly with a sharp hobby knife where each tap will be placed. This will make soldering the taps easier. Tin each of these spots lightly with your iron before soldering the taps in place. Form the four tap wires from resistor leads or solid wire that is well tinned. Don't try to use wire left

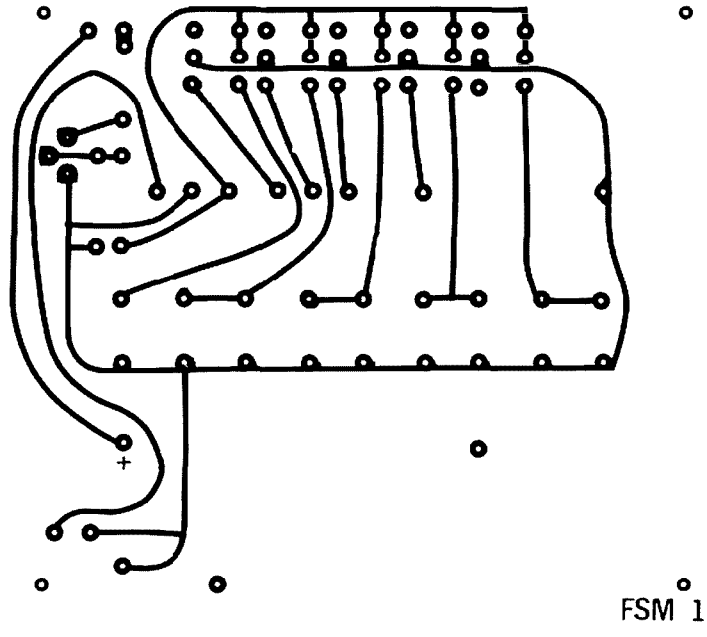


fig. 2. PC board, foil side, for the field-strength meter.

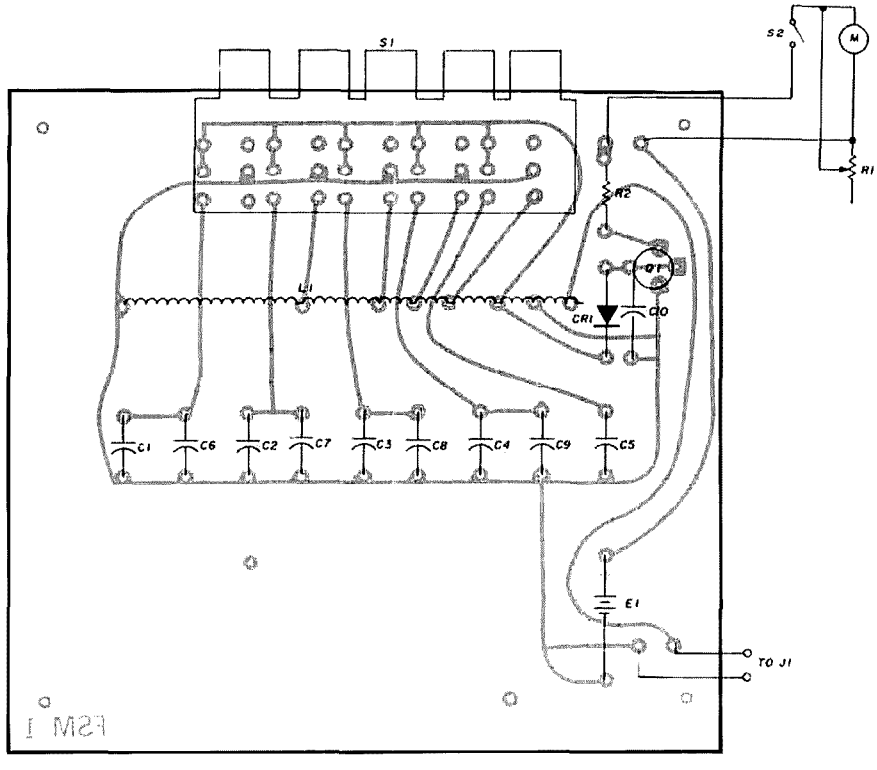


fig. 3. Component layout and associated wiring viewed from component side of PC board.

table 1. Parts list for the field strength meter.

component	description	part number	source*
C1 through C5	5 to 30 pF ceramic trimmer	E.F. Johnson 275-0430-005	CS
C6	150 pF ceramic cap	Sprague 5GA-T15	CS
C7	68 pF ceramic cap	Sprague 5GA-Q68	CS
C8	22 pF ceramic cap	Sprague 5GA-Q22	CS
C9	10 pF ceramic cap	Sprague 5GA-Q10	CS
C10	0.001-μF	Sprague 5GA-D10	CS
CR1	1N34A diode	276-1123	RS
E1	1.5 V "AA" cells (2X)	23-552	RS
E1 Holder	for 2 "AA" cells	12A2016-0	GM
J1	UHF jack, SO-239	278-201	RS
L1	1" × 16 turns/inch	B&W 3015	QE
M1	1 mA meter	Calectro D1-905	CS
Q1	transistor, germanium	276-2002	RS
R1	5 k pot, linear taper	271-1714	RS
R2	270-ohm, 1/2 W resistor	271-016	RS
S1	switch, 5-position pushbutton	18A1731-9	GM
S2	switch for R1	271-1740	RS
case	5-1/4" × 3" × 6"	270-253	RS
knob	0.750" diameter × 1/4" shaft	274-415	RS
spacers	No. 6 screw spacers	64-3024	RS
PC board	with S1 installed	FSM1	JO

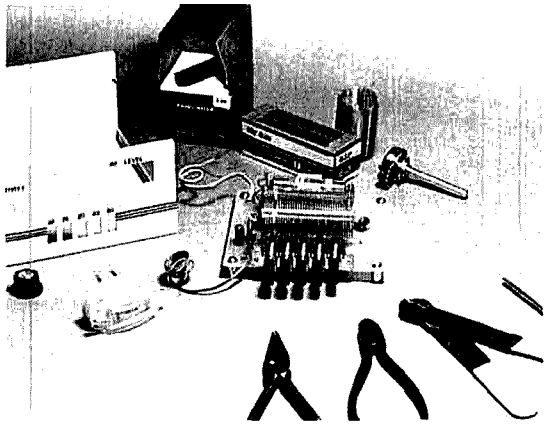
CS: Circuit Specialists
1344 N. Scottsdale Road
Tempe, AR 85281
Tel. 800-528-1417

GM: Gravois Merchandisers, Inc.
715 Armour Road
No. Kansas City, MO 64116
Tel. 800-821-3686

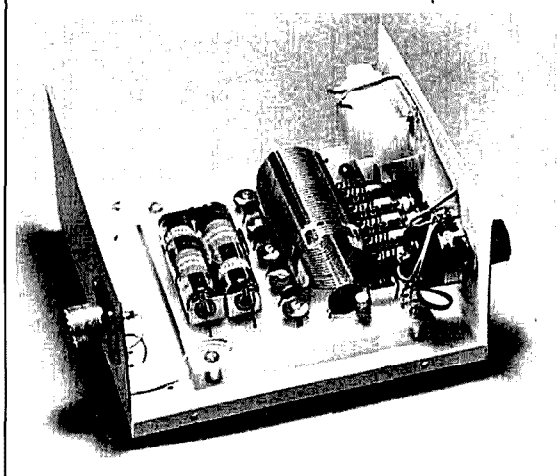
QE: Quement Electronics
1000 S. Bascom Avenue
San Jose, CA 95128
Tel. 408-998-5900

JO: Jim Oswald
1436 Gerhardt Avenue
San Jose, CA 95125
PC board with S1
installed $9.75 postpaid
Tel. 408-269-2314

RS: Radio Shack
Local stores



The field-strength meter ready for final assembly. PC-board construction and the use of pushbutton switches make a clean layout and an attractive package. Mounting screws for the meter are avoided by mounting the meter with epoxy cement.



Inside the field-strength meter showing, from left, the battery pack; rf tuned circuit consisting of L1 and C1 through C10; meter, and sensitivity control. Note that component layout pretty much follows the schematic diagram.

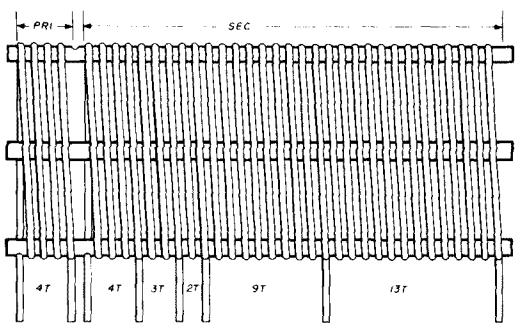


fig. 4. Details of rf-coil construction from standard coil stock.

over from the coil stock, as this is often difficult to solder in place.

Solder the four taps in place as shown in **fig. 4**. This operation is a bit tricky. Should you splash some excess solder on the coil form, it will lift off using solder wick or even a pipe cleaner.

After all the taps are in place, the coil leads can be trimmed to size and the coil can be mounted and soldered to the PC board. Don't get the tap leads too hot during this process or they may pop off the coil!

final details

Now that the PC board is complete, the mechanical details can be finished on the case. If desired, the case can be sanded with 320 or finer paper and a coat or two of your favorite color can be applied. I usually do this, as I invariably scuff up the front panel when making the required cutout.

After the paint is thoroughly dry, the rub-on lettering can be applied. This type of lettering and a few racing stripes can give your home projects a commercial look. A coat of clear lacquer will protect the lettering and level out the paint on the panel.

After all's dry, the PC board can be installed in the case and the sensitivity control, meter, and antenna jack mounted. The meter described in **table 1** has two small mounting holes. However, rather than use these, I mounted the meter with a couple of drops of epoxy cement between the front panel and the mounting tabs. This eliminated the mounting screws in the front panel and makes for a clean package.

The remaining wiring can be completed as shown in **fig. 3**, and the control knob can be installed on the sensitivity control. Give the unit a quick once-over against the schematic and drawings, then install the two AA cells, observing proper polarity. You are just about ready for the smoke test.

Turn the field-strength meter to **ON** and advance the sensitivity control slowly. As you advance clockwise, the meter will move slightly off the zero position in a positive direction. This is normal and indicates that all is well so far. Should the meter move slightly in the negative direction, the meter leads are reversed and must be transposed to correct the problem.

adjustment

The field-strength meter can be tuned with a signal source such as a signal generator, grid-dip meter, or your transmitter. If you use your transmitter, be sure to couple it to a dummy load so you don't radiate signals that will bother other Amateurs. In the absence of a dummy load, turn your transmitter output down and pick a time when the band is dead. Remember to listen on frequency before transmitting and keep each transmission short, ten seconds or less, and identify each transmission as a test transmission.

Choose your favorite frequency on the 80-meter band, and with the field-strength meter in the 80 position, inject a signal from the generator or use a pickup antenna for off-the-air or grid-dip signal source.

Adjust trimmer capacitor C1 for a maximum meter reading. Next, repeat this procedure with your signal source and the field-strength meter set for the 40-meter band. Trimmer capacitor C2 will provide adjustment for this band. Repeat this procedure for the 20-meter band, using C3 for adjustment. Capacitor C4 is for 15 meters, and C5 will be the trimmer for the 10-meter band. This completes the adjustment of the field-strength meter. The cover can be installed and you can sit back and admire your handiwork!

a final word

While the field-strength meter isn't a technological breakthrough or a state-of-the-art device by today's standards, it's a good project for getting started in the fascinating field of home brew. It will help you gain the skills necessary to go on to bigger, better, and more interesting projects. Most first-time builders will be able to complete the project during a weekend once the parts have been procured. And keep in mind that if you do have any problems or areas that are confusing you, ask one of your Amateur buddies for a bit of help. You will both enjoy the project!

The next project? Well, I hope to put an SWR meter together soon, and when we're armed with the field-strength meter *and* an SWR meter, there won't be a tune-up problem we can't handle. So do a good job on the field-strength meter and watch for the SWR meter soon.

ham radio

super beep circuit
for repeaters

Here's a circuit for your repeater that features an inhibit and selectable wait function

A beep signal in your repeater, if used properly, could be an asset; otherwise it's nothing more than another piece of trivial hardware. The super beep circuit, described here, was designed to provide the following:

1. An inhibit function against fluttering signals, as from mobile stations.

2. A selectable wait function to allow breakers to start a conversation before the beep signal is activated.

3. An adjustable duration of two independent audio oscillators, which generate a mellow and pleasant sound.

4. A high-level audio output to drive most repeater circuits.

The super beep circuit was designed for the Upper-Valley Amateur Radio Club repeater (Dayton, Ohio) using a VHF Engineering COR board. Input to the beep circuit, **fig. 1**, is obtained from the PTT point on the COR board. Output from the beep circuit feeds the audio input to the repeater's transmitter.

The super beep circuit uses standard TTL and CMOS logic, operating from a 5-volt supply. As shown in **fig. 1**, the circuit consists of an inhibit one-shot, a wait one-shot, and the two triggered audio oscillators. A buffer amplifier isolates and drives the repeater's audio input.

inhibit function

The inhibit function of the circuit is provided by U1, a 555 timer used as a monostable, which is made retriggerable by connecting a diode (CR1) between pins 6 and 2 (**fig. 2**). When the squelch from the repeater is broken, the PTT signal on the COR board, normally at logic 1, is forced to a logic 0. This action makes U1 pin 2 a logic 1. So long as the repeater's COR board keeps the PTT signal low, the output of U1 will stay high, and no timing function will be permitted since CR1 will not allow the timing capacitor to charge.

By **Al Torres, KP4AQI**, 4850 Hollywreath Court, Dayton, Ohio 45424

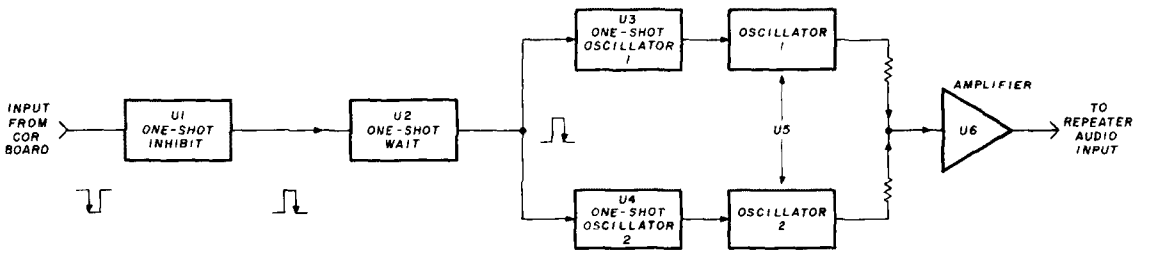


fig. 1. Block diagram of the super beep circuit, which uses standard TTL and CMOS logic. Two triggered oscillators provide the beep tone.

If the COR signal momentarily switches states (as during mobile flutter), the timing cycle of U1 is initiated. This timing cycle was designed to keep U1 pin 3 at logic 1 for 0.75 second after the COR signal changes state. If the COR signal recovers before 0.75 second, U1 pin **3** will not change state, and the timing cycle is aborted (see **fig. 3**). Keep in mind that the wait one-shot is activated only on transitions that *go from high to low.*

wait function

This function is implemented by using a 74121 (U2, **fig. 2**) as a monostable. The time duration of this one-shot is determined by:

$$T_D = K_d R_T C_T \left(1 + \frac{0.7}{R_T}\right) \quad (1)$$

where:

T_D = time duration (seconds)
K_d = constant supplied by manufacturer (ND)

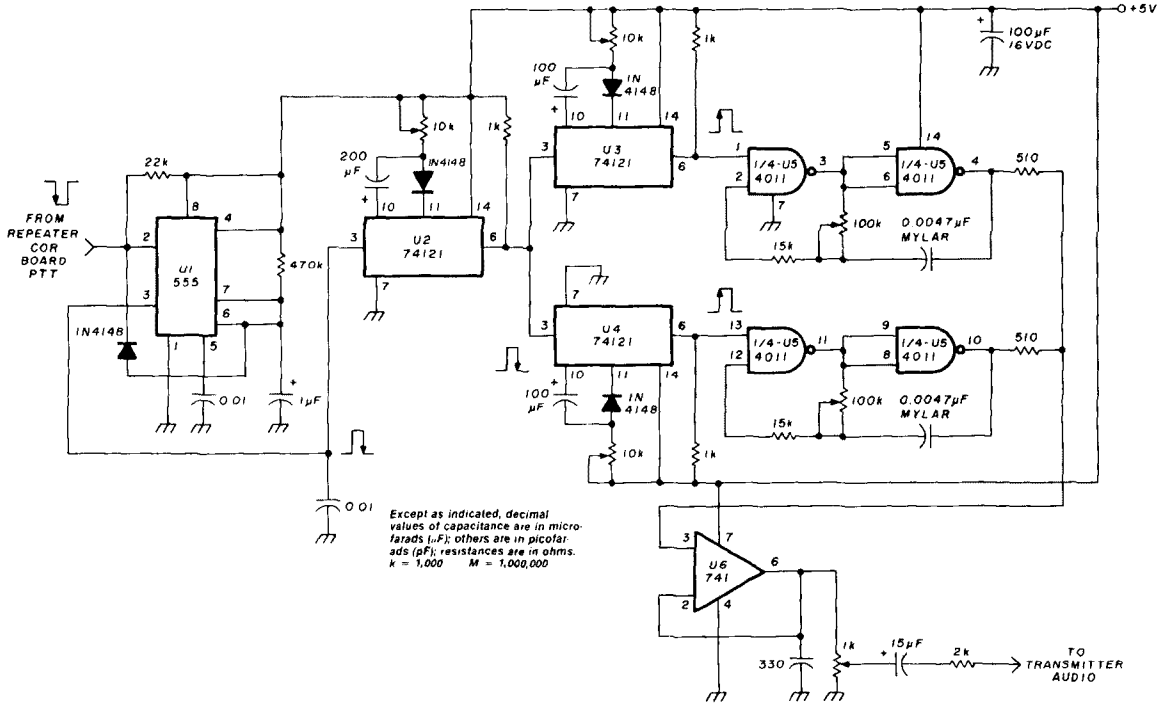


fig. 2. Schematic diagram of the super beep circuit.

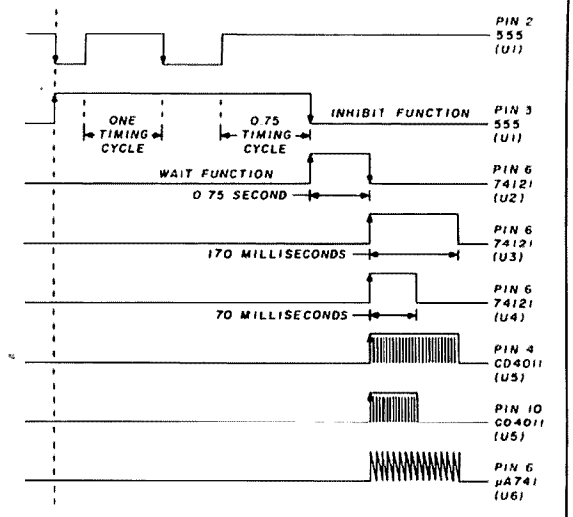


fig. 3. Super beep circuit timing diagram.

C_T = capacitance (farads)
R_T = resistance (ohms)

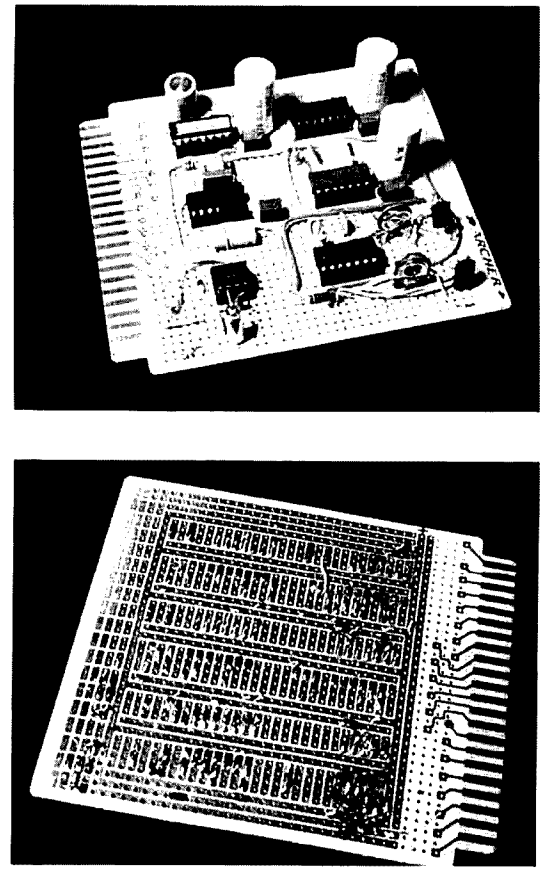
With the values shown, the one shot can be adjusted from more than 100 milliseconds to more than 2 seconds. In practice, I found that 0.75 second was optimum; such time duration, in addition to the 0.75 second from the inhibit circuit (a total of 1.5 seconds), is enough time for someone to break in between transmissions and before the beep signal is activated.

oscillators

The oscillators use CMOS logic (U5, a CD4011) and operate in the gated mode. When the input to the first gate is at logic 0 no audio is generated. Using this concept, the oscillators are fired for a fixed-time duration; control for such time duration is accomplished by two one-shots (U3 and U4). By making U3's duration longer than that of U4, a pleasant, mellow sound is generated.

The pitch of each oscillator is controlled by a 100k pot, which can be adjusted to satisfy your taste. After careful experimentation with our system, we made U3's duration approximately 170 milliseconds and U4's just 70 milliseconds. Results showed that a ratio of 3:1 creates the most pleasant sound. The audio is then coupled to the repeater through two 510-ohm resistors to a unity-gain voltage follower (U6), a μA741 op amp. Audio level is controlled by a 1k pot.

The input impedance of this voltage follower is such that no loading occurs at the CMOS audio oscillators. Audio range, with the components used, is adjustable from 1000 Hz to 10 kHz.



Super beep circuit was constructed on a Radio Shack edge-card board.

construction

The super beep circuit was built on a Radio Shack two-voltage-source edge-card board (RS 276-154), which mates to a 22-pin dual edge-card socket (RS 276-1551). The ICs were mounted in DIP sockets, which were soldered to the board.

Nothing is critical about the circuit. The unit operates from 5.0 Vdc, which is available on most popular repeaters. Current drain is not significant.

When adjusting the audio level, make sure that you provide enough audio to deviate your repeater 4-4.5 kHz; any greater amount will become bothersome to the operators and to adjacent repeaters.

ham radio

Questions and Answers

Entries must be by letter or post card *only. No telephone requests will be accepted. All entries will be acknowledged when received. Those judged to be most informative to the most Amateurs will be published. Questions must relate to Amateur Radio.*

Readers are invited to send a card with the question they feel is most useful that appears in each issue. Each month's winner will receive a prize. We will give a prize for the most popular question of the year. In the case of two or more questions on the same subject, the one arriving the earliest will be used.

I notice that pattern plots for beam antennas show the beamwidth at the 3-dB down points. Why is this figure used rather than, say, the 4- or 5-dB down point? — Sylvester McCutheon.

The 3-dB down point for antenna beamwidth measurements is a convenient reference point. The beamwidth is the angular distance between the directions at which the received or transmitted power is 0.707 times its maximum value, also called the half-power point.

I've moved a number of times in the last couple of years. The way I understand the FCC regulations is that if I move I have to notify the FCC — unless it is a temporary move. But what amount of time is considered temporary? — David Carrington, WL7ACD.

The FCC rules pertaining to addresses of licensees are contained in Sections 97.43 and 97.44. Basically, these rules state that you must furnish the FCC with an address in the United States where they can reach you with correspondence and documents (pink tickets, for example). Furthermore, every Amateur Radio station shall have one land location, the address of which appears on the station license, and at least one control point. Unless advised otherwise, the Commission will use the address contained in your most recent application to contact you.

After reading an article in which negative resistance was mentioned, I have wondered just what this term means. — Ted Brice.

Some devices have a property that exhibits a characteristic opposite to Ohm's law for positive resistance. This property, called negative resistance, is characterized by a decrease in voltage drop across the device as current through it is increased, or vice versa. Alternatively, a decrease in current through the device will occur as voltage across the device is increased, or vice versa.

A tunnel diode is an example of a device that exhibits negative resistance. The characteristic curve of the tunnel diode, which shows forward current as a function of forward voltage, contains an area where the diode's current decreases with increased voltage. This, of course, is opposite to the behavior of a regular resistor, which permits a greater current to flow as the voltage increases. The reverse condition occurs in the diode over this range of voltages; thus it is said to have negative resistance. With suitable external circuits added, it can be used as an oscillator or amplifier.

My TH6DXX antenna is on a 105-foot tower, and a 2300-MHz TV down converter is on the same tower at the 45-foot level. When I run about 800 watts input on 15 meters, the television screen goes blank and the down converter is inoperative. I have no interference problem with the down converter disconnected. The interference does not occur when operating on any other Amateur high-frequency band. Is the problem caused by overload on the down converter, and if so, why only on 15 meters? — Jim Brown, N4DDS.

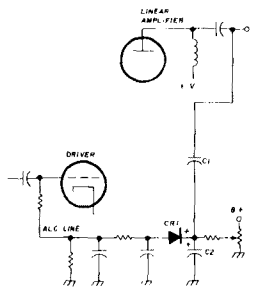
The transmission line from your converter to the TV set might be some length that is resonant at 21 MHz. So even if you disconnect the converter and don't remove the feedline, the latter will act like a beautiful antenna. Try putting a shorted quarter-wave stub (at 21 MHz) at the input to the TV set. The problem should then disappear.

What is the best location for a multiband vertical antenna — on the ground, on the roof, or on top of a mast? — Richard L. Beaty, KA5DDG.

The antenna should be mounted as high above ground and as far from surrounding objects as possible. In any case, a good ground system is important for a vertical antenna to work efficiently. Most vertical-antenna ground systems consist of radial wires arranged around the base of the antenna. It is not absolutely necessary that the radials form the spokes of a wheel; they can be run in almost any convenient manner. Installing radials on a mast-mounted vertical is more difficult than if the antenna is ground mounted, of course. However, you can use the radials as guy wires *and* slope them downward at an angle of, say, 45 degrees from the horizontal. This arrangement will make the antenna's feedpoint impedance closer to that of 50-ohm coax than if the wires were run horizontally.

Would you discuss ALC in some detail? I can't find anything on the subject in any authoritative source, including ARRL publications or my manual for my Yaesu FT-101. — Harold F. Keenan, WA1FJR.

ALC is an acronym for both *Automatic Level Control* and *Automatic Load Control*. The former is used with speech amplifiers in the radiobroadcast service. In the Amateur-Radio Service, the latter term describes a form of compressor, or automatic variable-gain amplifier, which is used in SSB transmitters. Automatic load control keeps SSB transmitter gain at the highest usable level without exceeding the peak-power capability of the power amplifier — a sort of insurance policy.



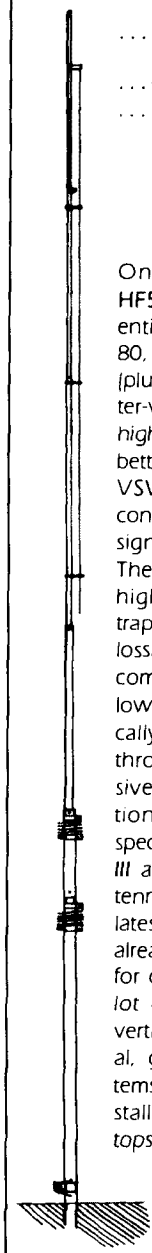
In the simplified circuit shown, which is used with zero-biased triodes, the power-amplifier tube draws grid current over a certain portion of each excitation cycle. C1 and C2 divide the rf voltage in the amplifier plate circuit. The rf voltage produced across C2 is rectified by CR1, which is connected so that its dc output voltage is negative. This negative dc voltage is applied to the control grid of a remote-cutoff tube in the driver to reduce the gain of the driver stage on signal peaks.

Other circuit elements provide appropriate attack and release time constants and bias. The overall effect of ALC is to keep the rf output relatively constant and at a level below the point where the amplifier is overdriven by widely varying audio input.

ham radio

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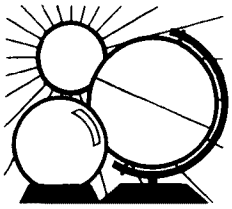


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DX FORECASTER

last-minute predictions

Very good conditions on the lower-frequency bands are expected during the first few days, perhaps through the first week, of July, then another good period is expected during the third week of the month. The DX conditions for the higher-frequency bands should improve steadily until the third week. During this time the daylight hours into the evening will be favored. Some disturbance is expected for a day or two in the first week, again around the 15th, and possibly of longer duration near the 21st of the month.

events of the month

Geophysical events that may affect DX on various bands are plentiful this July. The moon comes on stage with a partial eclipse on the day it is full (July 17th). The eclipse begins at 0325 and ends at 0609 UT. It can be seen from Africa except in the northeast; southwestern Europe; Antarctica; South America; North America except the northwest; the east Pacific; and New Zealand. The maximum obscurity of moon diameter is 0.55. Lunar perigee is on the 27th.

The sun is the big performer, with a total eclipse on the 31st beginning at 0111 and ending at 0620 UT, with a maximum duration of two minutes, two seconds. The path of totality begins on the Arabian Peninsula then extends across the southern Black Sea, northern Caspian Sea, into the USSR and China border, across Japan and Hawaii, and into Alaska and Northern Canada. Near the path of totality radio propagation goes from day conditions (high-frequency ham bands) to night conditions (lower-frequency ham bands) and returns to daytime conditions in just a couple of hours.

When daytime conditions return after totality, look for DX from unusual locations, as extra ionized layers are usually formed, which change slowly in height from the E to F region. The extra layer will support only nighttime radio frequencies near totality, changing slowly to daytime frequencies at the end of the eclipse. It should be fun to try some of the frequencies for DX if your QTH is near the path of the eclipse. Hams have in years past participated in eclipse propagation experiments.

The Aquarid meteor shower starts about the 18th, peaks about the 28th, and lasts until about August 7th. The radio-echo rate at maximum is about 34 per hour.

more on sporadic E (Es) DX

Before the Es season gets further along, a few more observations come to mind about using Es propagation in DX hunting. The *DX Forecaster* for May, 1981, went into some geophysical aspects of Es production. This was to give DXers an idea of where and when to look for summer short skip. Some antenna design considerations, to be able to couple well into the E propagation mode, were mentioned.

To try to short skip into a DX location use the following antenna takeoff angles and bearings: the takeoff angle should be around 5 degrees to make a hop length of 900 miles (1500 km) to obtain maximum signal strength of about 60 dB above a microvolt. To obtain the highest probability of being able to use the Es when it occurs, a fairly wide beamwidth should be used. That is, a small beam is better than a rhombic, and a wide-angle beam is better than a narrow one. Another rule is to use the lowest high-frequency band commensurate with the higher daytime versus nighttime absorption of the signal and the static. In other words, in the daytime don't use the 10-meter band when 20 is available or use 40 meters at night when 80 meters is available (if the static is not very bad); 6-7 dB are available for this difference in Es frequency range.

band-by-band forecast

Ten meters should provide excellent daytime propagation, particularly north/south path DX to South America, Africa and Pacific areas. Expect conditions to peak during the afternoon hours. There will also be some good short-skip sporadic-E conditions on many days of the month to distances between 500 and 1500 miles (800-2400 km) or more.

Fifteen meters will provide good worldwide DX during the daylight and early evening hours on most days of the month. Expect conditions to peak during the late afternoon, with long- and short-skip signals.

Twenty meters will be open to some area of the world for the entire twenty-four hour period on most days of the month. The band should peak in all directions just after local sunrise, and again toward the east and south during late evening hours. During darkness, the band will peak toward the west, in an arc from southwest through northwest, that will take in Pacific areas.

Forty meters can often provide good DX from sunset, through darkness, until just after sunrise, despite the atmospheric noise levels (static) — provided you choose times when local thunderstorm-related static is at a minimum.

Eighty meters can sometimes provide openings to DX areas during darkness and at sunrise, but signals will be weak and static will be strong. For these DX conditions, coastal stations often have a better chance of working DX than do stations in the center of large land masses.

One-sixty meters is almost hopeless during the hours of darkness and during the daytime. Forget it!

ham radio

*Look at next **higher** band for possible openings.

GMT	PDT	WESTERN USA N	NE	E	SE	S	SW	W	NW	MDT	MID USA N	NE	E	SE	S	SW	W	NW	CDT	EDT	EASTERN USA N	NE	E	SE	S	SW	W	NW
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a new look at the W8JK antenna

This old standby provides interesting possibilities for the new bands

By Frank Regier, OD5CG, Department of Electrical Engineering, American University of Beirut, Beirut, Lebanon

The W8JK antenna or "flat-top beam" was adapted for Amateur use and described in *QST* in 1938[1] by John D. Kraus, W8JK. This antenna was widely used for several years but has now been largely superseded by the Yagi, which has higher gain for a given size.

In 1970, 32 years after his original *QST* article, W8JK described a 5-band rotary beam antenna with several modes of operation.[2] In mode 1, having the highest gain, the antenna consists of a pair of vertical W8JK antennas stacked horizontally. Whether by design or chance, the same issue of *QST* contains a description of a device called "The Ultimate Transmatch,"[3] which is a considerable aid in making the basic W8JK an attractive antenna.

In this article the W8JK antenna is compared to the widely-used 3-element Yagi, and it will be shown that, despite its lower theoretical gain, the W8JK is in several respects the better antenna.

the W8JK antenna

The basic W8JK antenna is shown in **fig. 1**. It consists of two closely spaced dipoles fed 180 degrees out of phase. The original W8JK article refers to this as a single-section antenna if the dipole length, L, is a half wavelength and as a two-section antenna if L is a full wavelength. In fact, the antenna operates well and with no abrupt change in properties over a frequency range such that L varies from less than a half wavelength to more than a full wavelength, so that this distinction appears unnecessary. In the original article and elsewhere[4] more complicated varieties of the antenna, and end-fed as well as center-fed versions, are discussed. However, only the basic antenna is dealt with here.

Operation of the W8JK antenna is as follows: the individual dipoles tend to radiate as they would in isolation; that is, with no radiation off the ends and maximum radiation at right angles to each dipole. However, because of the out-of-phase feed to the dipoles, radiation cancels in the upward and downward directions. The cancelled radiation is not lost but appears elsewhere, primarily in both directions along a line joining the centers of the two dipoles.

Antenna gain depends on both element length L and spacing d, but neither is critical. If a lossless antenna is assumed, very close spacing should produce the highest theoretical gain, but such spacing also results in very low radiation resistance, and conductor losses cannot then be neglected. In practice, spacings of about one-eighth wavelength seem to be opti-

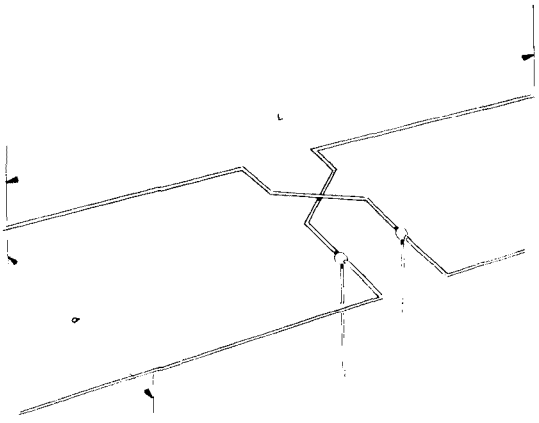


fig. 1. The basic W8JK antenna, consisting of two closely spaced dipoles fed out of phase.

mum. The spacing should not be reduced to much below this figure but can be increased to a quarter wavelength with very little reduction in gain.

Antenna length is subject to the same constraints as in the case of a simple dipole: length should not be reduced much below a half wavelength because of reduced radiation resistance, and gain increases with length up to a maximum at one and a quarter wavelengths.

The gain of a basic W8JK antenna with eighth-wavelength spacing and half-wavelength elements is about 4 dB in free space. This figure increases gradually to about 6 dB at twice the design frequency, and to a maximum of about 7 dB at 2.5 times the design frequency.

the Yagi antenna

The familiar 3-element Yagi antenna is shown in **fig. 2.** This antenna is similar to the W8JK in that its

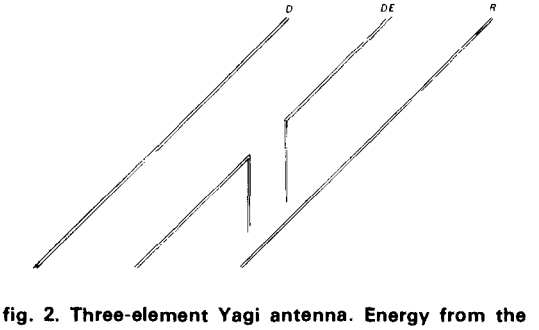


fig. 2. Three-element Yagi antenna. Energy from the driven element DE is picked up and reradiated by reflector R and director D.

gain results from the cancellation of radiation from the various elements in some directions and addition in others. It differs, however, in how power is applied to the various elements. In the W8JK antenna both elements are fed directly. In the Yagi only one element is fed directly, and the others behave simultaneously as receiving and transmitting antennas, receiving power from the driven element and re-radiating it with an amplitude and phase determined by the length of the element and its spacing from the driven element. This method of supplying power to the parasitic elements makes the Yagi easy to feed, but the critical dependence of the phase of radiated power on element length makes the Yagi a narrow-band antenna, operating as intended only near the design frequency. At frequencies far removed from resonance, the parasitic reflector and director receive and re-radiate little power, and the pattern of the antenna is not very different from that of the driven element alone.

Variations on the 3-element Yagi include: a) an increase in the number of directors, leading to improved forward gain (additional reflectors, being in a low-field region, would have little effect and are rarely used), b) interlacing elements for various frequency ranges, and c) the addition of traps in the various elements to cause resonance at several frequencies. This is a useful procedure but requires compromise spacing at the different frequencies.

a comparison

Although a 3-element Yagi has more gain in free space than the W8JK, there are at least three respects in which the latter is the better antenna. These are: noncritical construction, bandwidth, and operation at low elevation.

The noncritical nature of the W8JK results from the fact that, unlike the Yagi, it does not depend on resonance for its symmetry; and, provided symmetry is maintained, element length and spacing are relatively unimportant.

Its large bandwidth, too, results from the nonresonant nature of the W8JK antenna. This bandwidth is such that operation is possible over at least a 2.5:1 frequency range. Operation over such a range does require the use of an antenna tuner or transmatch and a tuned transmission line, since antenna impedance does change with frequency.

antenna height

We turn now to the question of operation at low elevation. It is a matter of great importance, and in fact the major point of this article, that the basic principle of operation of the W8JK antenna remains valid even at very low elevations, whereas under the same conditions the behavior of a Yagi degrades to that of

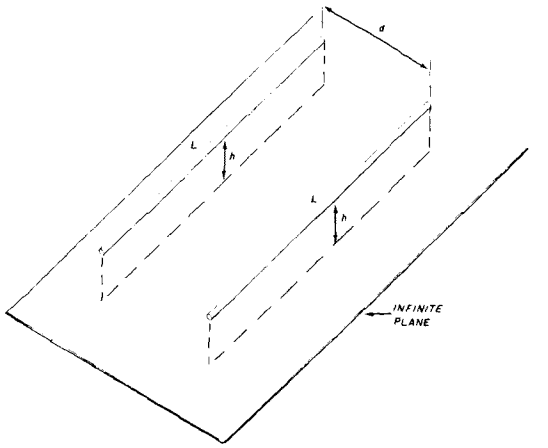


fig. 3. Basic W8JK antenna spaced at a height h above a ground plane. Although reflection from the ground plane takes place and the angle of radiation is raised, symmetry is retained, and the basic principle of operation — cancellation of radiation in the vertical direction — remains valid.

a simple dipole. This means that at low elevation the W8JK is a more effective antenna than the Yagi. To see why this is so, consider first the W8JK (see **fig. 3**). The presence of a nearby ground plane will affect the antenna impedance, but with a tuned feed line and a transmatch this is easily compensated.

The important point is that, because symmetry is not disturbed by the ground plane, the fundamental principle of operation — cancellation of radiation in the vertical direction — remains valid. Considering next the Yagi (see **fig. 4**), we find that the nearby ground plane will severely detune both director and reflector and interfere with their excitation by the driven element. These two parasitic elements therefore become ineffective, and performance degrades to that of a simple dipole near ground.

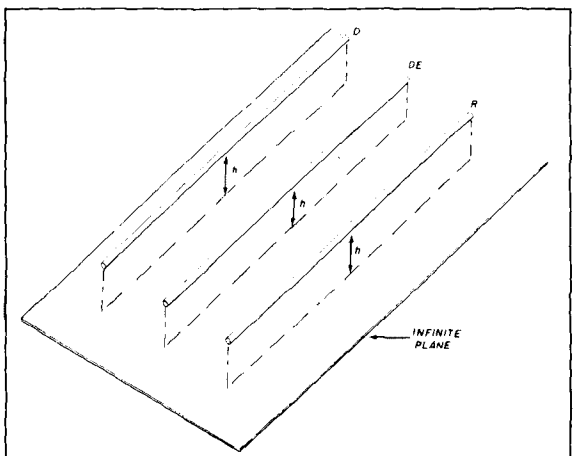


fig. 4. Three-element Yagi antenna at a height h above a ground plane. If h is small, director D and reflector R are detuned and improperly excited and are thus ineffective. The resultant radiation pattern is that of the driven element DE alone — a dipole above a ground plane.

It follows from the above argument that there must be some critical height below which the W8JK outperforms the Yagi, and it would be interesting to know what that height is. In principle it should, of course, be possible to calculate the characteristics of both the W8JK and the Yagi as functions of height above a perfect ground. But, particularly in the case of the Yagi, this presents difficulties, and an experimental approach *seems* preferable. I am not in a position to carry out the experimental work, but I have found a reference[5] that seems to contain the essential results. In this reference it is stated that a 20-meter antenna, essentially equivalent to a W8JK, at 38 feet (11.6 meters) gave results comparable to a 3-element Yagi at the same height. When 10-meter antennas were compared at the same height, the 3-element Yagi was found to be superior. This would seem to imply that at an elevation of about one wavelength, a 3-element Yagi outperforms a W8JK, but that at a half wavelength elevation, the two are about equal. This would mean that the critical height is about a half wavelength, and that below that height a W8JK can be expected to outperform a Yagi.

Fig. 5 (from reference 4) shows the W8JK vertical radiation pattern at a height of 1/2 wavelength.

conclusions and remarks

The W8JK antenna has a number of desirable characteristics and makes a particularly good antenna in situations where only a low height is possible. An elevation of a half wavelength seems to be about the critical height below which the W8JK provides higher gain than a 3-element Yagi. Thus a W8JK at 20 feet (6 meters) should be about comparable to a 3-element Yagi at the same height on 21 MHz, poorer at higher frequencies, and better at lower frequencies.

Although the W8JK exhibits gain over at least a 2.5:1 frequency range, the antenna has an impedance that is a function of frequency and should be fed by a transmatch and an open-wire line of some sort.

In addition to the 10-, 15-, and 20-meter bands, the new Amateur bands at 10, 18, and 24 MHz can be ac-

commodated. For example, an antenna with a length $L = 40$ *feet* (12 meters) and a spacing $d = 11$ *feet* (3.4 meters) should provide good performance on the Amateur bands at 10, 14, 18, 21, 24, and 28 MHz. In addition it should provide much improved reception on the 12-, 15-, 18-, and 21-MHz shortwave broadcast bands, where most listeners make do with a random length of wire, or at best, a dipole. If operation below 14 MHz is not required, the spacing can be reduced to $d = 8$ *feet* (2.4 meters), and the length L can be anything from 24-40 feet (7.3-12.2 meters).

In closing I might mention that my own experience in feeding a 30-foot-long (9-meter) W8JK with 8-foot (2.4-meter) spacing by means of a 40-foot (12.2-meter) length of 300-ohm TV twinlead has been better than might be expected. There has been no breakdown with 1200 watts PEP input, and although losses are no doubt somewhat higher than those of an open-wire line, the use of twinlead is extremely

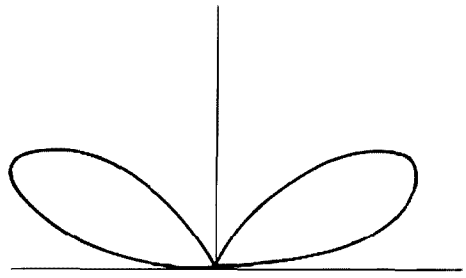


fig. 5. Vertical pattern of W8JK antenna at a height *h* of one-half wavelength. At other heights additional lobes may appear, but vertical radiation is always cancelled and radiation is at lower angles than from a dipole at the same height (from reference 4).

convenient. The main disadvantage of the twinlead is that it is necessary to cease operation during rainstorms because the input impedance of the feed line becomes erratic.

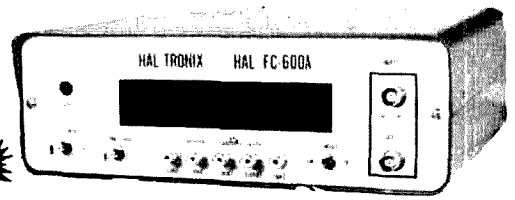
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3. L. McCoy, "The Ultimate Transmatch," *QST*, July, 1970, page 24.
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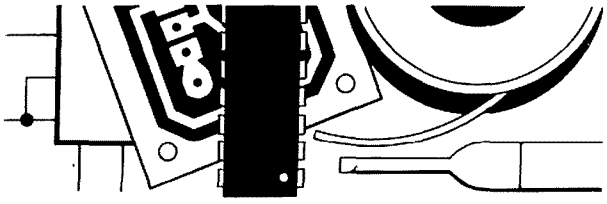
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the weekender



a 2-way ashtray for your car

Mounting a handheld transceiver (HT) in your car any place other than on the front seat can sometimes be a problem — particularly if you want to be able to remove it easily. I found a simple solution that works well for me, with only about one evening's work. My Toyota Corolla (like most cars) has an ashtray in a convenient and accessible location on the front dash. It suddenly seemed obvious (particularly as I no longer smoke) that this would be an ideal location for mounting my radio. The sketch in **fig. 1** is for a bracket to hold a Kenwood TR-2400, although the dimensions and design can be altered to suit any HT.

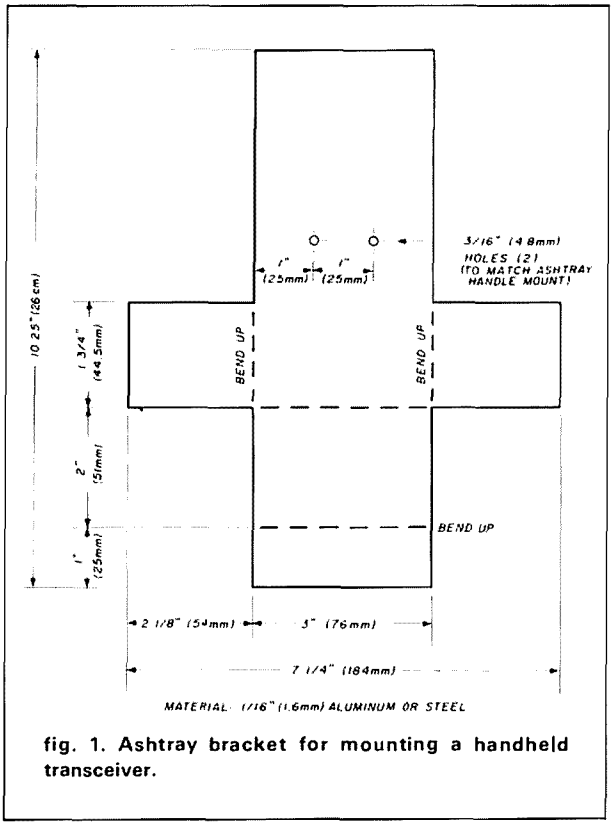
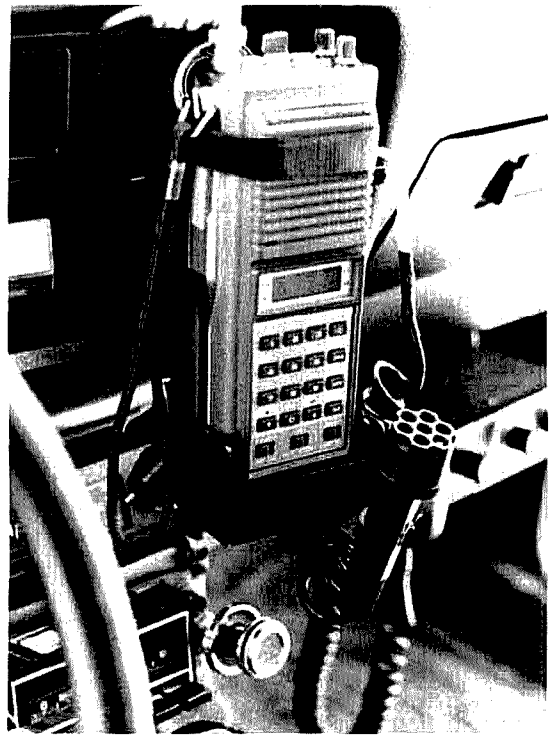


fig. 1. Ashtray bracket for mounting a handheld transceiver.

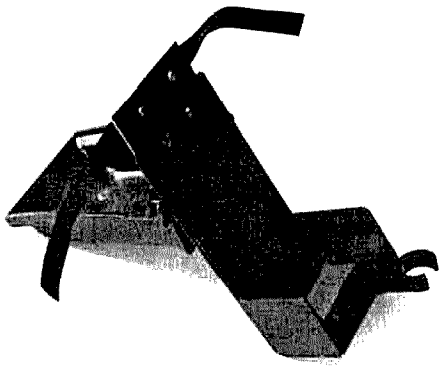
By Herb Bresnick, KB2XM, 16 Creekside Drive, Honeoye Falls, New York 14472



Handheld in ashtray mount makes a convenient mobile installation.



Radio and ashtray mount removed from car and resting on table.



Homebrew mounting bracket fastens to the front of automobile ashtray.

Since the tone pad is on the front of the radio, the bracket is cut higher on the sides and lower in the front to permit access.

The ashtray is removed from the dash by simply pulling it beyond the normal stop position. Some ashtrays require pressing a tab so they can be removed for emptying. The plastic pull is next unscrewed from the inside and removed, leaving a flat mounting surface. The same holes can be used for attaching the bracket.

After the bracket was bent, a coat of black enamel was applied and the inside lined with self-stick, felt contact-paper to protect the set from scratches. A small piece of foam on the bottom absorbs shocks while you're driving, further protecting your set. I used a strip of Velcro™ to hold the top part of the radio to the bracket, although a small leather strap would work as well.

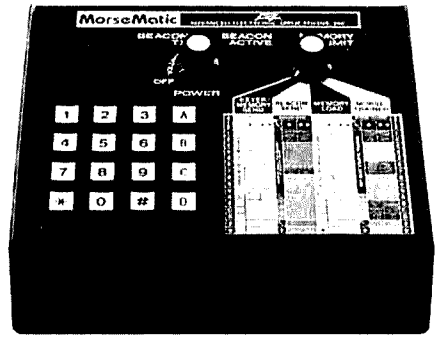
One advantage of this mount is that it can be easily slid out for quick removal. It also functions as a simple stand on a table, and the ashtray even holds accessories (charger, earphone, and so on).

As a further refinement, I mounted a microphone holder on the lower front of the bracket and plugged an external microphone into the microphone jack, so that the entire radio doesn't have to be lifted out for talking. A low-impedance dynamic cassette microphone, with a series 0.5-μF capacitor was found to work fine with the TR-2400. The microphone is light and compact, and the plugs mate exactly with the radio jacks. I replaced the original cable with a coil cord for added convenience.

This was a fun project and has considerably improved the utility of my HT as a mobile rig. Incidentally, if you are a smoker, this is good incentive to quit smoking!

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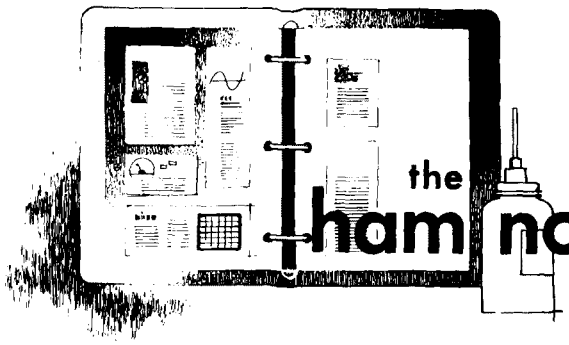
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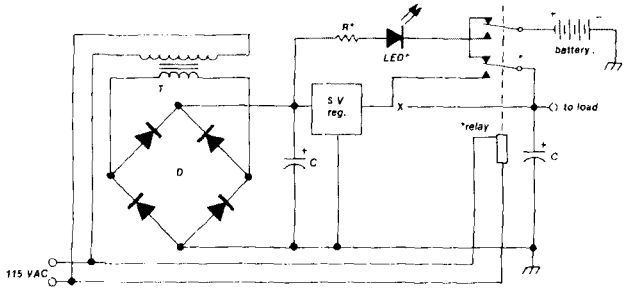
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X	cut PC board foil here	*	additional parts

fig. 1.

battery backup for the K4EEU frequency standard

Because of frequent power failures in my area, I made the modifications shown in **fig. 1** to Bert Kelley's "Universal Frequency Standard," which was published in *ham radio*, for February, 1974.

When line power is on, it provides load power as well as charging current of near 50 mA as the battery approaches the discharged condition. However, because of the nonlinearity of the LED, current is reduced to below 10 mA trickle charge as the battery nears the fully charged state. It takes about 140 per cent of the battery rated ampere-hour (AH) capacity to fully charge a nicad at the normal rate. Typically it is AH/10 × 14 hours, or a trickle charge of AH/150 continuously, depending on the amount and duration of power failures.

As shown, the battery will provide backup power for about eight hours at the normal load rate of 150 mA. When fully charged, the battery reads near 5.5 volts but in minutes reduces to 5.2 volts when discharging. At this voltage the frequency standard runs about +5 Hz in 10^7. For about 80 per cent of the battery discharge cycle, the battery voltage is relatively stable near 4.8 volts, and the frequency standard runs near normal frequency. When the battery nears discharge (below 4.4 volts), the standard runs about −5 Hz in 10^7. However, when line power returns, the standard returns to normal in minutes instead of requiring days to regain normal frequency stability.

John R. True, N4BA

516F-2 low-voltage and bias modification

Owners of Collins 516F-2 power supplies who have changed from vacuum-tube rectifiers to solid-state devices should check the low-voltage supply potential. This supply is nominally given a 275-volt value under load and will rise to approximately 300 volts during standby. With the use of silicon rectifiers, an increase of 10 per cent in these values might be expected, but I found it (in two cases) to be closer to 20 per cent. This means the voltage during keydown would be 330 volts and during standby would rise to 360 volts. While this had no immediate detrimental effects, I felt that this condition isn't one that's in the best interests of equipment longevity!

Fortunately, the secondary of the low-voltage-supply transformer has a center tap lead separate from the high-voltage winding. Two parallel 600-ohm, 10-watt resistors were inserted between this lead and chassis ground (**fig. 2**). A terminal strip or insulated standoff was mounted near

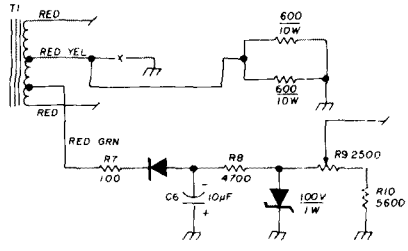


fig. 2.

the chassis side rail beneath the filter chokes. The center tap lead of the low-voltage secondary winding was lifted from its ground connection at the terminal strip close to the line cord entry and reconnected at the junction of the terminal strip and resistors. The resistors were placed along this side rail as well.

When I was done, I found the low voltage to be within a few volts of the recommended value. A check should be made of the paralleled combina-

tion of R-89/R-112 (32S-1) or R-140 (32S-3) since these resistors in the cathode circuit of the exciter's VOX relay tube run at their maximum power ratings, especially in the 32S-1; later model 32S-3s have a higher-power resistor here.

While working beneath the power-supply chassis, I added a 100-volt, 1-watt zener diode (HEP Z0438) between R8 and R9 junction. This device held the bias voltage to within a volt or so of its set value, whereas before this addition the bias wandered considerably with the changing transformer load during CW keying.

Paul K. Pagel, N1FB

trimming the dipole antenna

A formula for finding the length in feet of a halfwave wire to be used as a dipole antenna is 468/f (MHz). This is a good starting place but is usually not exactly correct.

To find the correct length the easy way, find the constant for your antenna location and height: this is a number near 468 and correct for your antenna.

Erect your dipole in its final position after determining the length by the above formula. Then find the frequency where the VSWR is lowest for this length. Multiply this frequency in MHz by the number of feet used. The number will be somewhere near 468. Now, recompute the length using this new constant instead of 468.

Example: You need a dipole with low VSWR at 7.2 MHz. The constant 468 divided by 7.2 is 65. Put up the dipole in its final position with 32.5 feet (9.9 meters) on each side. The lowest VSWR is at 7.15 MHz. Multiply $7.15 \times 65 = 464.75$. This is the constant you should have used; you have the antenna out there to prove it! This time use $464.75/7.2$. Answer: about 64.55 feet (19.7 meters). If you shorten the antenna by about 2-3/4 inches (70 mm) on each side, you will be on 7.2 MHz.

All this doesn't mean you're going to have zero reflected power at 7.2 MHz; it means your antenna will have the lowest VSWR at 7.2 MHz. Chances are small that you'll have the antenna in just the right place to present 50 ohms of resistive impedance to your feed line, and this is the reason for the small amount of reflected power remaining.

E.R. Lamprecht, W5NPD

radio interference to shortwave receivers

A troublesome source of interference to shortwave receivers is known as ITV. That's interference caused by the horizontal sweep oscillator in TV sets. It produces harmonics that cause hash every 15 kHz or so in your receiver. Cures for ITV have been described in numerous Amateur publications.

But what about other sources of interference to your receiver? An excellent description and some cures are found in reference 1, an article by the late Jim Fisk that appeared in an early issue of *ham radio*. Jim described causes of and cures for interference produced by TV receivers, electric-motor-powered appliances, fluorescent lights, power lines, neon signs, diathermy machines, furnace igniters, and TV boosters.

new interference sources

Now come some new interference sources. For example, I recently purchased an ion generator. That's a gadget that is supposed to produce a healthful environment by shooting out ionized particles. It also shoots out a lot of rf interference. It wasn't long before I heard a new noise in my receiver — and so did my neighbors. In fact, when I put a key into the power line to the ion generator, I was able to send spark signals (damped waves) all over the neighborhood. (I haven't figured out how to eliminate this source of interference, except by turning off the ion generator.)

Other sources of RFI (radio interference) are light dimmers and digital clocks. Some digital clocks have a small disk that rotates about once per second and produces a noise that can be heard some distance away in shortwave receivers.

Finding cures for this type of interference means working patiently with a sensitive monitoring device, locating the source, and then taking appropriate action with filters.

No one prohibits the sale of these interference-producing devices. They may crop up in your neighborhood any time. So if you hear a strange noise in your receiver, start looking at some of your new appliances. You might be surprised.

reference

1. Jim Fisk, W1DTY, "Radio-Frequency Interference," *ham radio*, December, 1970, page 12.

Ed Marriner, W6XM

ac-line switching precautions

A friend called me the other day and said that he'd used his equipment just before dinner and when he left the room, he turned "everything off." A few hours later my friend went into the radio room and smelled something burning. His linear-amplifier transformer had burned out!

"How could this have happened?" he asked. "I turned the switch off." It developed that my friend had a

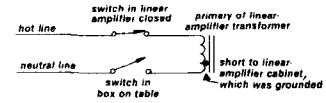


fig. 3.

heavy-duty cord running into a box on the operating table through a single-pole wall switch, since he had an ordinary two-wire plug on the end of the cord. It looked like he was breaking the *neutral* instead of the *hot* side of the ac line, since the linear amplifier was grounded. It wasn't too hard to understand that the transformer was still on the line. (See **fig. 3**).

Orville Gulseth, W5PGG



New Product Report

Several years ago, in one of the April Fool's articles that appeared in *QST*, there was a design for a hydraulic antenna mast that retracted into the ground. As I remember the story, you had to drill a hole as deep as the mast was high. To raise or lower the mast you filled the hole with water. At least at that time it seemed like an April Fool's article.

Now, N-Pro, from Oregon City, Oregon, has designed and perfected an antenna mast that can be used in much the same fashion! Their design, however, goes way beyond the *QST* article and is rapidly finding a home in both ham and professional applications. TV stations, for example, are putting both cameras and antennas for their remote-site shots onto N-Pro masts. They find they're able to get better pictures from an elevated camera, and also improve their transmitted signals. The N-Pro K2 mast extends to 22 feet 2 inches, and can lift 150 pounds in just under two minutes. When retracted the mast is only 7 feet 6 inches long. The K2 is fabricated from four sections of 6061-T6 aluminum alloy. The pipe sections are splined to prevent antenna or camera rotation during elevation.

The K2 uses easy-to-find automotive automatic transmission fluid, rather than any of the more expensive hydraulic fluids. The hydraulic reservoir and pump can be conveniently located anywhere in the vehicle.

Hams will find the N-Pro masts of interest for mobile communications centers, VHF hilltopping installations, and for field day operations. For the ultimate in hidden antennas, you can even bury the mast as was done in the *QST* article. For more information, write N-Pro, 1022 Hazelwood Drive, Oregon City, Oregon 97045.

J. Craig Clark, N1ACH

Ten-Tec Argosy

Ten-Tec's new Argosy solid-state transceiver reverses the upward Amateur Radio price spiral with an Amateur net price of $549, hundreds of dollars lower than you would expect for a high performance transceiver. Dual power is a unique feature: a switch converts the Argosy from a 10-watt QRPp rig to a 100-watt SSB/CW transceiver.

The Argosy receiver features 80 through 10 meter coverage (including the new 30-meter band) with broadband design for instant band change without receiver "peaking"; typical sensitivity figure of 0.3 μV for 10 dB S+N/N; 2.5 kHz four-pole crystal filter (plus optional 1.8-kHz, 500-Hz and 250-Hz filters); 9-MHz i-f with 60 dB rejection; $\pm$3-kHz offset tuning with center "off" position; built-in 50 dB notch filter that's tunable from 200 Hz to 3.5 kHz; optional i-f type 50-dB noise blanker; and built-in speaker with low distortion audio.

The transmitter features tuning in nine 500-kHz segments (four segments for 10 meters) with approximately 40-kHz VFO overrun on each band edge; 100 percent duty cycle up to 20 minutes on all bands; three-function meter shows forward peak power or SWR on transmit and received signal strength; full break-in on CW plus PTT on SSB; built-in sidetone with adjustable tone and volume; ALC control on high power only, where needed; automatic sideband selection plus reverse; normal 12-14 Vdc operation plus ac operation with optional power supply.

Styling includes molded *front* panel, matching aluminum top, side and back panels. Size is 4 × 9½ × 12 inches, to fit and go anywhere. A full accessory line is available including filters, noise blanker, audio CW filter, and calibrator. Full details are available from Ten-Tec, Inc., Highway 411 East, Sevierville, Tennessee 37862.

book review: *The Art of Electronics*

Many books are submitted to us for review, but here's one that deserves special attention. It's a 716-page, hard-bound volume entitled *The Art of Electronics*, written by Paul Horowitz and Winfield Hill. The publisher: Cambridge University Press, 32 East 57 Street, New York, New York 10022. (It is also available in the United Kingdom for overseas readers.)

We like this book. It is written for the newcomer as well as the advanced electronics enthusiast. The book covers the design of modern electronic circuits, without mathematics, in an easy-to-understand manner. Just a few of the subjects:

- Current sources and current mirrors
- Single-supply operational-amplifier design
- Operational-amplifier frequency compensation
- Active filters (with tables and graphs)
- Voltage references and regulators, including constant-current supplies

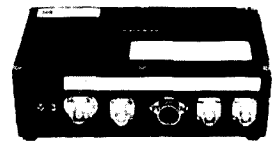
The book is both novel in its approach and, in many ways, unique in the topics treated. Much emphasis is placed on tabular data and circuit examples, so that you can understand circuit behavior and the limitations imposed by available components. Standard topics are discussed, as well as the more specialized techniques needed for the design and construction of high-frequency and low-noise, high-precision circuits.

The book provides a well-balanced introduction to modern electronics

TRANSVERTERS FOR ATV OSCARS 7, 8 & PHASE 3

Transverters by Microwave Modules and other manufacturers can convert your existing Low Band rig to operate on the VHF & UHF bands. Models also available for 2M to 70cm and for ATV operators from Ch2/Ch3 to 70cms. Each transverter contains both a Tx up-converter and a Rx down-converter. Write for details of the largest selection available.

Prices start at $199.95 plus $4.50 shipping.



SPECIFICATIONS

Output Power	10 W	Receiver Gain	30 dB typ.
Receiver N.F.	3 dB typ.	Prime Power	12V DC

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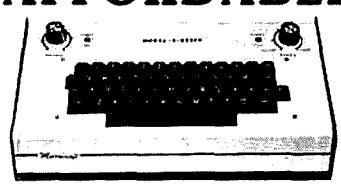
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A new, hand held, 3½-digit LCD DMM has just been introduced by EICO Electronic Instrument Co., priced at $89.95 including fitted carrying case. The EICO 274 measures ac and dc volts, dc current, and resistance in 21 ranges.

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For further information contact EICO Electronic Instrument Co., Inc., 108 New South Road, Hickville, New York 11801.

packaging and breadboarding materials

A twelve-page brochure from Vector Electronic Company describes 109 professional electronic packaging and breadboarding products that are available, over-the-counter, from electronics and personal-computer-component stores throughout the United States and Canada. Highlighted are microcomputer interface boards, Vector Plugbords™, motherboards, cases, tools, wiring terminals, and kits. A complete price list is included. Write to Vector Electronic Company, Inc., 12460 Gladstone Avenue, Sylmar, California 91342.

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HAM CALENDAR

July

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
W1AW Schedule **April 26-October 25, 1981** UTC Slow Code Practice: MWF: 0200, 1300, 2300; TThSSn: 2000; S: 0200 Fast Code Practice: MWF: 2000; TTh: 0200, 1300; TThSSn: 2300; S: 0200 CW Bulletins: Dy: 0000, 0300, 2100; MTWThF: 1400 Code practice and CW bulletin frequencies: 1.835, 3.58, 7.08, 14.08, 21.08, 28.08, 50.08, 147.555 MHz.			**WEST COAST QUALIFYING RUN 1** **CANADA CONTEST** 001 to 2359 UTC 1 **1**	**NIAGARA PENINSULA ARC** CJ3VM will be operated by club members on 80-10 meters. Special QSL cards available via POB 692, St. Catharines ON L2R 6Y3 2-7 **2**	**3**	**RAC ANNUAL FIRECRACKER HAMFEST** – Shelisville VFW picnic grounds Harrisburg PA 4 **HANNIBAL AMATEUR RADIO CLUB INC** – National Tom Sawyer Days – Clifford Ahrens Hannibal ARC, 2108 Orchard Ave, Hannibal MO 63401 4-5 **VENEZUELAN SSB CONTEST** – Starts 0000 GMT Sat. Ends 2400 GMT Sun 4-5* **4**
5	**WEST COAST BULLETIN** – 8PM PST (0400UTC) 3540 KCS, A-1 22WPM 6 **6**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **7**	**W1AW QUALIFYING RUN 8** **INTERNATIONAL CONVENTION** Independent County Hunters Net & Mobile Amateur Radio Awards Club Jim Dixen (CHN, MARAC, RRS Box 576, Norwalk IA 50211 8-11 **8**	**9**	**10**	**IARU RADIOSPORT CHAMPIONSHIP 11-12*** **BLACK RIVER ARC** – Special Event Station K1BZ – on or near 3.975, 7.275, 14.275, 21.375 & 28.375. Contact The National Blueberry Fest, POB 224, South Haven MI 49090 11-19 **BURLINGTON ARC'S SEVENTH ANNUAL ONTARIO HAMFEST** – Milton Fairgrounds, south of intersection of Hwys 401 & 25, Burlington, ON – B.A.R.C. Box 832 Burlington ON L7R 3Y7 11-13 **11**
WISCONSIN NETS ASSOCIATION ANNUAL PICNIC/HAMFEST Gene Santoski K9UTQ 12 **GENESEE RADIO AMATEURS FIRST ANNUAL HAMFEST** Alexander Firemen's Grounds, Route 98, Alexander NY – for info send SASE to GRAM Inc Box 572, Batavia NY 14020 12 **BROADCASTER'S ARC FOURTH ANNUAL HAMFEST** Pocono Downs Race Track, Rte 315, Wilkes-Barre PA – Charles Baltimore, 67 S Franklin St., Wilkes Barre PA 18773 12 **12**	**13**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **14**	**15**	**16**	**SWOT QSO PARTY 17-23** **17**	**NEW HAMPSHIRE FM ASSOCIATION** – Electronic flea market at Manchester Municipal Airport – Dick DeRosiers W1KGZ 18 **CARY ARC NINTH ANNUAL MID SUMMER SWAPFEST** Cary ARC, POB 53, Cary NC 27511 18 **12TH ANNIVERSARY OPERATION NEIL ARMSTRONG** – Neil Armstrong Air & Space Museum Wapakoneta, OH – Gary Stolzenburg, 717 W Benton St, Wapakoneta OH 45895 18-19* **FORT WAYNE RADIO CLUB'S ANNUAL THREE RIVERS FEST** special events certificate Robert Marshall, POB 15127, Fort Wayne IN 46885 18-19 **18**
AGCW DL QRP CONTEST 18-19* **COLUMBIAN CONTEST** – 18-19* **SEANET C.W. CONTEST** 18-19* **WEST JERSEY RADIO AMATEURS 3RD ANNUAL HAMFEST** McGuire Air Force Base, Wrightstown NJ – for info contact WB2LCC 19 **STRAITS AREA ARC ANNUAL HAMFEST** Harbor Springs H.S., Harbor Springs MI Bernie Stormick, 630 Ann St., Harbor Springs MI 49740 19 **TUSCE ARC & CANTON ARC'S SEVENTH ANNUAL HALL OF FAME HAMFEST** Nimishillen Grange 6461 Eastern St. Louisville OH – WA8SHP 19 **19**	**WEST COAST BULLETIN** – 8PM PST (0400UTC) 3540 KCS, A-1 22WPM 20 **20**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **21**	**W1AW QUALIFYING RUN 22** **22**	**23**	**MACKINAC RACE EVENT** 24-26* **WEST GULF DIVISION ARRL CONVENTION** contact Central Oklahoma Radio Amateurs POB 20118, Oklahoma City OK 73120 24-26 **24**	**4TH ANNUAL NOARSFEST** – ARRL approved – Lorain County Fairgrounds, Rte 58 on Rte 18, Lorain OH – contact NOARSFEST, POB 354, Lorain OH 44052 25 **PENTICTON ARC'S OKANAGAN INTERNATIONAL HAMFEST** – Oliver Centennial Park, Oliver, BC Canada – contact John Anderson VE7DTX 25-26 **SHAWANO CENTENNIAL EXPO** – Franklin Middle School Radio Club – special event station – contact WA9BZW 25-26 **VENEZUELAN C.W. CONTEST** – 25-26* **ARRL NATIONAL CONVENTION** – Seattle WA – contact W7OM 25-27 **COUNTY HUNTERS C.W. CONTEST** – 25-27* **25**
AMATEUR RADIO PUBLIC SERVICE ASSOCIATION SWAP & SHOP St. Joseph County Fairgrounds, M-86, Centerville MI 49091 – 26 **MADISON COUNTY ARC HAMFEST** National Guard Armory on 109 Bypass, Anderson IN, Everett Riley, RR4 Box 354 Alexandria IN 46001 – 26 **26**	**27**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **28**	**29**	**30**	**MONTANA WIMU HAMFEST** Yellowstone MT – contact N7AIK 31 **31**	*See June CQ

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Coming Events

ACTIVITIES

"Places to go..."

ILLINOIS: Radio Expo '81 sponsored by the Chicago FM Club will be held, rain or shine, on September 19th and 20th at the Lake County Fair Grounds, routes 45 and 120 in Grayslake. Grayslake is 30 minutes north of Chicago and 45 minutes south of Milwaukee. This year we will have a super large flea market with plenty of indoor and outdoor space, free with a gate ticket. Just bring your own table and chair or tailgate it. Parking is free. We will also have new camping sites complete with power hookups. There will be Ham seminars both Saturday and Sunday. YL's have a ladies program and door prizes both days. Only the best manufacturers of Ham and computer equipment and their distributors will be at our huge display building for you to meet and buy from. As in the past, Expo will be giving out thousands of dollars worth of prizes and admission tickets are good for both days. For advanced registration, send $3.00 per person and a #10 S.A.S.E. to Radio Expo Tickets, P.O. Box 1532, Evanston, Illinois. Tickets at the gate are $4.00 each. Kids under seven are free. For more information call (312) BST-EXPO. Talk-in on 146.16/.76, 146.52, and 222.5/224.10.

SOUTHERN ILLINOIS: Shawnee Amateur Radio Association's 25th anniversity Silver Jubilee Hamfest will be August 30 at JOHN A. LOGAN College in Cartersville, Illinois. Offerings include Air Conditioned Flea Market — Prizes — Forums — Computers — Food — Refreshments — Contests. For details OSL Bill May, KB9QY, 800 Hilldale, Herrin, IL 62948 or (618) 942-2511 days.

ILLINOIS: The Belvidere Hamfest on August 2nd, rain or shine, at the Boone County Fairgrounds, Hwy. 76. Camping available. Will be held rain or shine. Indoor facilities available with tables at a nominal charge. Contact Bob Anderson, 910 W. Locust St., Belvidere, Illinois 61008 for advance tickets at $2.00 (S.A.S.E. please) or telephone at (815) 544-3215.

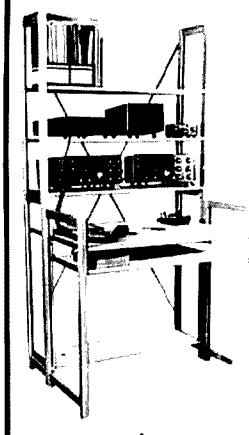
INDIANA: The Madison County A.R.C.'s MCARC Hamfes' on July 26th starting at 8:00 A.M. at the National Guard Armory on the Rt. 109 bypass in Anderson. Dealers set up at 7:00. Advanced tickets: $2.50. Vendor spaces without tables: $1.75 and w/tables: $2.50. Admission at the door: $3.50. Door prizes and more. Talk-in on 146.22 and 146.52 simplex. Advanced tickets and space contact: Everett G. Riley, RR #4, Box 354, Alexandria, IN 46001.

INDIANA: The Steuben County Radio Amateurs present the 23rd annual Crooked Lake FM Picnic and Hamfest in Angola, Indiana on August 2nd.

INDIANA: The annual LaPorte County Hamfest, sponsored by the LaPorte and Michigan City A.R.C.'s will be held, rain or shine, on August 30th at the County Fairgrounds on Highway 2, west of LaPorte (50 miles S.E. of Chicago). Overnight trailer parking available. Paved flea market area. Indoor tables are $1.00. Satellite TV demonstration. Advanced tickets $2.00 with S.A.S.E. to P.O. Box 30, LaPorte, Indiana 46350.

KANSAS: The Northwest Kansas first Amateur Radio Swap Meet on August 2nd at the Community Building, Colby, Kansas starting at 9:00. Auction at 2:00. Admission: $1.00, tables: $1.00 each (same for dealers). Talk-in

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MICHIGAN: The 33rd annual Upper Peninsula Hamfest sponsored by the Delta County Repeater Association on August 1st and 2nd in Escanaba at the Flat Rock Township Hall. Registration: $2.00. DX forum, ARPSC workshop, satellite-TV seminar, slow scan, net meetings and swap & shop. Many prizes and banquet. More info: Aileen Gagnon, WA8DHB, Kipling Loc., Mtd. Rte., Gladstone, Michigan 49837.

MICHIGAN: The Amateur Radio Public Service will hold a swap and shop on July 26th at the St. Joseph County Fair Grounds, M-86, in Centerville. Admission: $2.00. Tables: $3.00. Gates open at 7:00. Talk-in on 146.52 simplex.

MISSOURI: The third annual Northcentral Missouri Hamfest on August 2nd in Moberly at the air conditioned Municipal Auditorium. Doors open at 9:00. Tickets: $1.50 advanced and $2.00 at the door. Commercial dealers & flea market (no charge for tables). ARRL display, exhibits, prizes, women's activities, and a special forum featuring Bob Heil, K9EID, on CB to ten meter conversions. Buffet lunch plus more. Talk-in on 147.69/.09 and 3963. More info: Charles Coy, WB@ENV, 601 McKinley, Moberly, Missouri 65270.

NEW HAMPSHIRE: Fly-in to New Hampshire's 3rd largest electronic flea market on July 18th at the Manchester Municipal Airport starting at 9:00. Sponsored by the New Hampshire FM Association. Admission: 50¢; Dealers: $2.00. Sellers should bring their own table or tailgate. Commercial displays welcome. Refreshments and door prizes. Talk-in on 146.52 FM and 124.9 AM. More info: Dick DesRosiers, W1KGZ, (603) 668-8880 or Doug Aiken, K1WPM, 30 Meadowglen Dr., Manchester, NH 03103. (603) 622-0831.

NEW JERSEY: The 3rd annual West Jersey Radio Amateurs hamfest on July 19th at McGuire A.F.B. in Wrightson. Admission: $2.50. Starts at 9:00. Table spaces and outdoor tailgating: $2.50. Bring your own tables. Contests, films, refreshments and more. Prizes every 15 minutes. Talk-in on 146.52 simplex and 147.15 and 145.47 repeat. Advanced tickets or info: Bill Luebkemann, WB2LCC, 116 Country Farm Rd., Box 140, Marlton, NJ 08053. (609) 983-8844 daily 6 p.m. until midnight. S.A.S.E. appreciated.

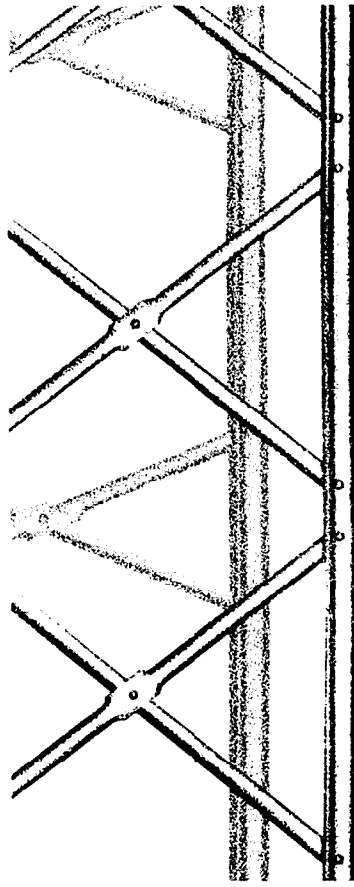
NEW JERSEY: The Gloucester County A.R.C.'s G.C.A.R.C. Hamfest on August 30th at the Gloucester County College, Tanyard Road in Sewell from 8:00 to 3:00. Admission: $2.00 advanced and $2.50 at the door. Tailgaters and dealers: $6.00 (includes one free admission). Speakers, seminars, prizes and contests. Free parking, handicapped parking, food and beverages. F.C.C. exams will be given for Tech through Advanced. Please write or call for details. Dealers set-up at 7:00. Talk-in on 146.52 and 147.78/.18. Info and reservations: S.A.S.E. to G.C.A.R.C. Hamfest Committee, P.O. Box 370, Pitman, NJ 08071. Telephone day: (609) 456-0500 or (609) 338-4841. Evening: (609) 629-2064.

PENNSYLVANIA: Philadelphia's Mid-Atlantic A.R.C.'s annual J.B.M. Hamfest on August 9th at the Budco 309 Drive-In Theatre, Montgomeryville (¼ mile north of the intersection of Route 63 and Route 309 and 6 miles north of the Fort Washington Interchange of the Pennsylvania Turnpike). Starts: 9:00 rain or shine. Hamfest will be combined with the Alternate Energy Fair. Major door prizes, refreshments, exhibits, flea market and more. Energy fair will include educational and commercial Alternative Energy Exhibitors featuring solar heating, building design, an energy devices flea market, alternative energy door prizes and much more. Admission: $2.50. Tailgaters: $1.00 for one space and 75¢ for every space after one. Talk-in on club repeater, WB3JOE, 147.66/.06 or 146.52 simplex. More info call Don Schuenemann, WB3AYT, (215) 822-9076.

TENNESSEE: The Radio Amateur Transmitting Society's (RATS) Nashville Hamfest on July 26th at the National Guard Armory, Sidco Dr., Nashville. Starts: 8:00. Admission: $2.00. Tables: $5.00 each. Refreshments available. Talk-in on .90/.30. More info: RATS, P.O. Box 2892, Nashville, Tennessee 37219.

VERMONT: The Burlington A.R.C.'s annual International Hamfest on August 8th and 9th at the Old Lantern Campground in Charlotte (14 miles south of Burlington, just off Route 7). Admission: $4.00 (U.S. funds). Flea market, commercial exhibits, CW contest, tower raising contest, HT transmitter hunt and the traditional Canadian-American tug of war. Talk-in on .34/.94. More info: Hap Preston, W1VSA, P.O. Box 312, Burlington, Vermont 05402. Campground reservations: 1-802-425-2120 (Old Lantern Campground, Charlotte).

WASHINGTON: The Radio Club of Tacoma's annual Hamfair on August 15th and 16th at the Pacific Lutheran



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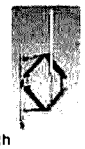
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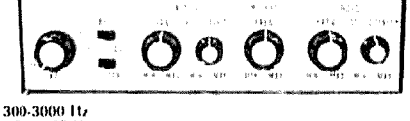
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CANADA: The Burlington A.R.C.'s seventh annual Ontario Hamfest on July 11th - 13th at the Milton Fairgrounds (south of the intersection of Hwys. 401 and 25, exit 39) in Burlington. Admission: $3.00 at the gate and $2.00 in advance (before June 15th). Gates open at noon on Friday and 7:00 on Saturday. Flea Market opens at 8:00. Tables free. Camping, food and lots of prizes. Talk-in on 147.81/.21. More info: B.A.R.C., Box 836, Burlington, Ontario, L7R 3Y7.

OPERATING EVENTS

"Things to do..."

MAY 30th - SEPTEMBER 6th: The Parma Radio Club will once again be operating from the WWII submarine, USS Cod using the club call, K8UZW. Operations will run every weekend (except the Field Day weekend) through September 6th. An attractive certificate will be awarded for 2-way contacts from the ship upon receipt of a QSL and 30¢ to cover postage. All bands will be operated, 10 to 80, band conditions will determine band of major activity. Send QSL's to: WD8RZG. Info: Don Winner, WD8RZG, 8927 Torrance Ave., Brooklyn, OH 44144.

JULY 2nd - 7th: CJ3VM will be operated by members of the Niagara Peninsula ARC from July 2-7/81, for the special anniversary celebrating the bi-centennial of Niagara-on-the-Lake, Ontario, and the bi-centennial Boy Scout Camporee. Operation will be on 80-10 meters. Special QSL cards will be available via P.O. Box 692, St. Catharines, Ontario. L2R 6Y3.

JULY 17th - 23rd: SWOT (Side-Winders-on-Two) is holding its fourth annual QSO party. Begins at 0000 UTC on the 17th and ends 2359 UTC on the 23rd. No restrictions on number of hours operated. Must exchange Call signs, Geographic location and SWOT members must include SWOT number. Must use CW or SSM mode and contacts must be made direct without the aid of satellites, etc. No logs should be submitted unless requested. Summary must be sent postmarked no later than August 21st. More info or summary: S.A.S.E. to Dean Figgins, WA7EPU, P.O. Box 1141, Carefree, AZ 85377.

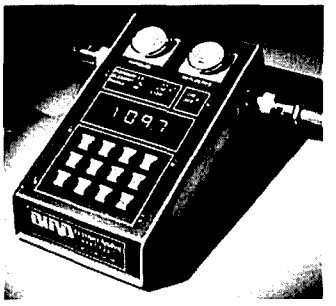
JULY 18th and 19th: The Neil Armstrong Air and Space Museum in Wapakoneta, Ohio is the operating place for the 12th anniversary commemorating Neil Armstrong's historic first walk on the moon. Wapakoneta is the hometown of Neil Armstrong. Hours: 9:00 AM on the 18th to 8:00 PM on the 19th local time. Two station on following frequencies depending on propagation conditions. 40M-CW: 7.075-7.125 (to help novices). 40M-Phone: 7.250-7.300. 75M-Phone: 3.950-4.000. 20M-CW: 14.1 ± 1 kHz. 20M-Phone: 14.300-14.350. 15M-Phone: 21.400-21.450. All frequencies may not be used, but we will operate as many as possible. WD8RVZ will be used. Commemorative OSL available with S.A.S.E. U.S. and Canadian QSL direct to WD8RVZ. All others, please use bureau. Visiting amateurs may check in on 147.93/.33, Wapakoneta DSA repeater.

JULY 25th: Buffalo, Wyoming Amateurs in cooperation with the Sheridan A.R.C. will operate SSB on or about 14.280 & 21.360 MHz under the call W7GUX. The station will be operated in honor of and during the Johnson County Centennial Celebration. Certificates will be awarded to all contacts that mail S.A.S.E. to: 7BVX, Bob Glenn, P.O. Box 383, Buffalo, Wyoming 82834.

JULY 25th and 26th: The Franklin Middle School Radio Club and Shawano area amateurs will operate a special event station from the Shawano County Fairgrounds in conjunction with the exposition honoring various Shawano groups for either 100 or 50 years of service. Hours: From 1800 UTC on the 25th to 1700 UTC on the 26th during times the bands are open. Frequencies plus or minus QRM: 3980, 7280, 14280, 21580, and 28580 as well as 146.52 for those in the area. OSL with business size S.A.S.E. and 25¢ for certificate or we'll be happy to exchange QSL cards with you. For certificates, cards, or further information: Al Hovey, Jr., WA9BZW, 314 Fairview Way, Shawano, WI 54166.

AUGUST 1st - 2nd: The nineteenth annual Illinois QSO Party from 1800Z August 1st to 2300Z August 2nd with a rest period from 0500Z to 1200Z on the 2nd. All bands, CW and Phone will be used. No repeater contacts allowed. Any frequency will be used, but look for activity about 60 kHz from low end on CW, about 3975, 7275, 14275, 21375 and 28675 on Phone and about 25 kHz from low end of each Novice band, especially on the hour and half hour. Exchange RST and county by Illinois stations

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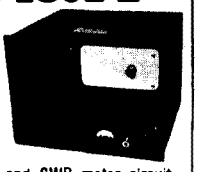
and RST, state, province and/or country by others. Certificates awarded to the top three Illinois scorers in single-op, multi-op, multi-multi, portable out of home county, mobile, Novice, and CW Tech. More info, S.A.S.E. to: RAMS/K9CJU, 3620 N. Oleander Ave., Chicago, IL 60634.

AUGUST 8th: The Radio Central A.R.C.'s unusual 24 hour mini-expedition to Little Gulf Island commencing August 8th at 1600Z to August 9th 1600Z. Call sign will be WA2UEC. Little Gulf Island is a small island in Long Island Sound about 15 miles northeast of Orient Point. Operations will be on the lower portions of the General bands, 10 to 80 meters, both CW and SSB. There will also be a Novice station operation. A photo QSL card will supply all information about the trip. Please QSL via callbook WA2UEC with S.A.S.E., the W2 Bureau or IRC's. This will be the first of a series of mini-expeditions.

AUGUST 15th - 17th: The Englewood A.R.A.'s 22nd annual New Jersey QSO Party starting 2000 UTC the 15th to 0700 UTC August 16th and from 1300 UTC the 16th to 0200 UTC the 17th. Phone and CW considered the same contest. General call is "CQ New Jersey" or "CQ NJ." New Jersey stations are requested to identify themselves by signing, "DE NJ" on CW or "New Jersey calling" on phone. Suggested frequencies are: 1810, 3535, 3900, 7035, 7135, 7235, 14035, 14280, 21100, 21355, 28100, 28610, 50-50.5, and 144-146. Phone activities on even hours, 15 meters on odd hours, (1500 to 2100 UTC) 160 meters at 0500 UTC. Exchange QSO number, RST, and OTH. Certificates awarded to first place station in each NJ county, ARRL section, and country. Novice and Tech certificates also awarded. More info S.A.S.E. to E.A.R.A., P.O. Box 528, Englewood, NJ 07631.

AUGUST 22nd - 23rd: The Ohio QSO Party from 0000Z on the 22nd to 2400Z on the 23rd. All dates and times are UTC. Contest open to all Amateurs world wide on any amateur band from 160 to and including 2 meters. Exchange RST and your QTH. Frequencies: 5 kHz up from the low end of each General band, both on SSB and CW. Club will operate near these frequencies using W8VPV. Plaques for top single operator in Ohio and outside Ohio. Certificates to the top single operator, multi-single, and multi-multi in each ARRL section, county (Ohio) and DXCC country. More info S.A.S.E. to The Cuyahoga Falls A.R.C., P.O. Box 6, Cuyahoga Falls, Ohio 44222.

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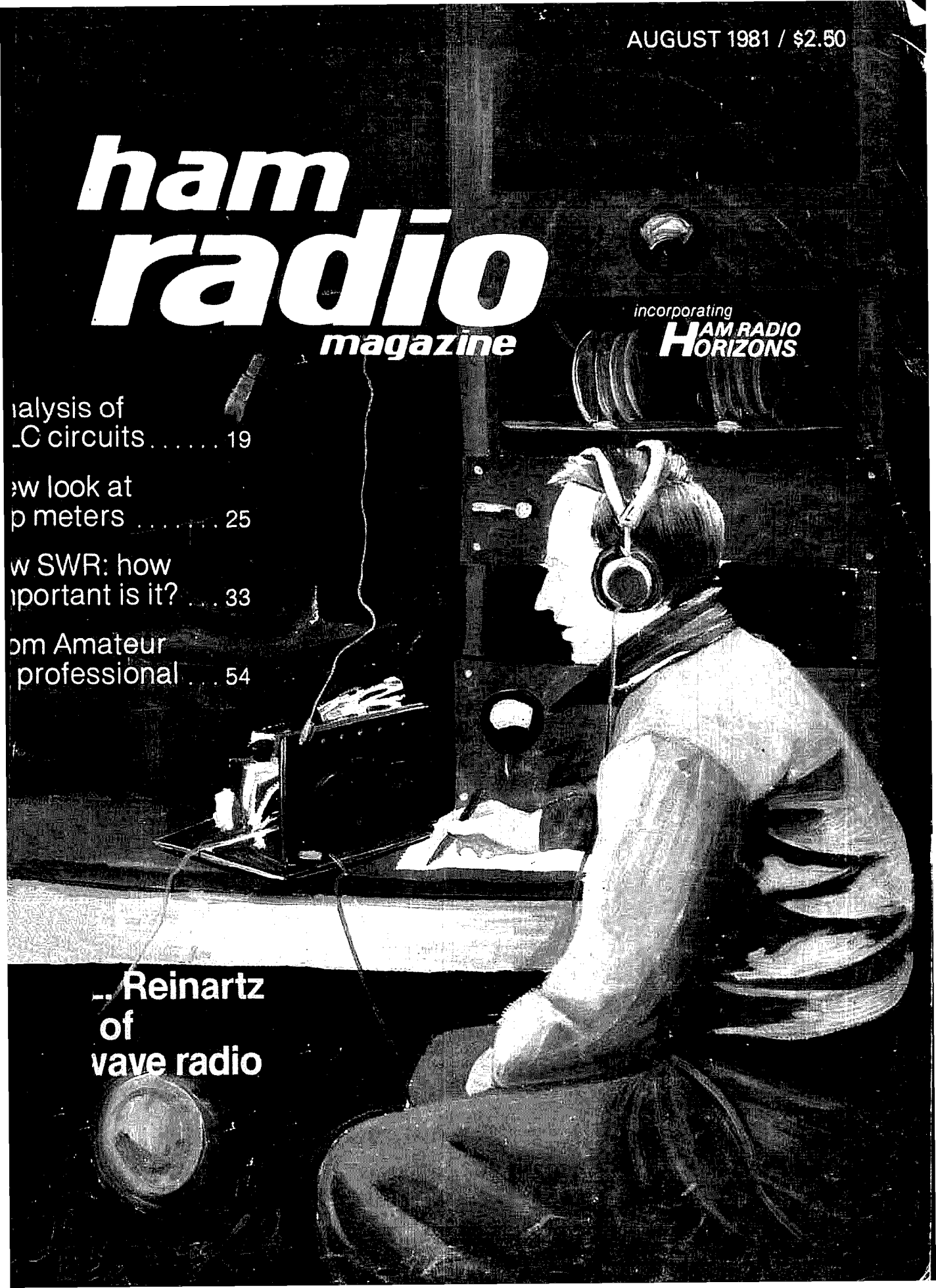
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HAM RADIO HORIZONS

AUGUST 1981

volume 14, number 8

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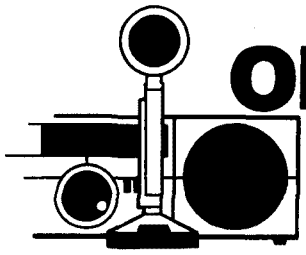
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Observation & Opinion

Automatic Load Control (ALC) was discussed briefly in last month's "Questions and Answers" column. Judging from some of the illegal SSB signals on the air, it seems that ALC is still a mystery to some and should be explored a little more thoroughly. Our guest editorial is by the author of just such an article, which appears in this issue. I'd like to introduce John Weber, K4JW.

Alf Wilson, W6NIF, Editor

To me, it's becoming more and more apparent that some of our phone bands are becoming impossible to enjoy, especially on weekends, because of heavy QRM. Being a "professional loafer," I can enjoy most of my phone operation during the week, usually keeping schedules with old friends around the country.

We have to keep some of these schedules in the General portion of 20 meters because some of our group are restricted to this portion of the band (not to say that the rest of the band is much different!), and many times we are forced to use our linears to plow through the adjacent QRM; thus we too add to the overall QRM level. Although ours is a technical hobby, it gives old friends a chance to meet and talk — no earth-shattering technical or philosophical discussions, just friendly get-togethers. But, when somebody "buckshots" from 4 to 7 kHz away, the enjoyment rapidly disappears.

Just think what a mess we would have if this were still a-m instead of SSB! While NBVM (which hasn't caught on) might help, and future spread-spectrum techniques will allow us to hop, skip, and jump all over the band with minimum QRM, I am afraid we must still deal with the situation as it is today.

One of our problems has been receiver design: old receivers cannot survive alongside present-day linears and high-gain directive antennas, with IMD being the problem usually impeding copy. Fortunately, manufacturers have made considerable improvements to contemporary receivers; with passband shifters, variable passband, and high-performance filters, it is possible to copy signals that would have been impossible to read on older receivers. I hope we all enhance the ability of our receivers to reject or minimize adjacent QRM by using the rf attenuator and backing off on the rf gain when conditions warrant.

Even so, when an Amateur runs his rig "wide-open," fails to monitor his signal output, and shouts into the mike, it gets pretty rough to tweak him out. For some reason, otherwise clean signals get very broad when the operator is running phone patches, suggesting somebody is not paying attention to modulation levels. Of course, these are operator-control problems. One problem it's possible to have and not be aware of is an incompatibility of ALC characteristics between the exciter and linear amplifier. This can occur because the exciter and linear were made by different manufacturers, or because they are of different generations: the 15-year-old linear and the 1981 transceiver. And, of course, maybe the ALC line isn't even connected — that's really an operator-control problem.

I have been using a term not well understood by some Amateurs — ALC. Somebody said it is not even mentioned any more in the *ARRL Handbook*. I think if you look under "Speech Processing" in the chapter on SSB you will find it; it did disappear from the index for some reason. ALC is a form of speech processing.

Now, if you would like to know more about ALC, I suggest you read the article entitled, "An Analysis of ALC Circuits" in this issue. With luck, it will help reduce splatter on the bands, and perhaps it will prod manufacturers into paying more attention to the design problem and into providing us with meaningful numbers so at least we know whether or not a "compatibility" problem exists.

John P. Weber, Jr., K4JW



comments

intruder watch

Dear **HR:**

In regard to W5SAD's letter on Amateur band intruders (October, 1980), W5SAD and others may find, as I have, that the following message sent in CW on the frequency that Russian intruders are using will often get them to shift out of the band:

*UI*TA *OE*ASTOTA *OE*ASTX
MEVDUNARODNOJ
L*IM*BITELXSKOJ POLOSY
*OE*ASTOT POVALUJSTA QSY
TOT*OE*ASVE

The italicized OE's, UI, and IM are run together to form the additional Cyrillic alphabet characters.

This message when taken down in Cyrillic script reads, "This frequency is part of the International Amateur band — please QSY immediately."

Whether or not you sign the message with your callsign will depend on your local rules. Here in ZL, Amateurs are not permitted to communicate with non-Amateur stations. This legal problem has been overcome by the issue of a special call of ZL6IW. I use this callsign to ask intruders to shift and this works in many cases, although it is sometimes necessary to keep on asking for long periods before they "get the message."

A fact that most Amateurs choose to ignore, whilst still bemoaning the presence of intruders, is that most of the intruders into our exclusive bands are there only because we allow them to be. Given the numbers and geographic spread of Amateur stations around the world, it is within our power to deny an intruder the use of any of our frequencies. Do not move aside for intruders when they come onto your frequency; you are the legitimate user of the Amateur band, not them. Protest the intrusion and continue to protest it in any way you can. Number 115 of the I.T.U. Regulations reads: "Administrations . . . shall not assign to a station any frequency in derogation of . . . the Table of Frequency Allocations given in this chapter . . . except on the express condition that harmful interference shall not be caused to services carried on by stations operating in accordance with the provisions . . . of these regulations." It follows that, unless an intrusion is protested, the intruders' administration has the right to assume that its stations are not causing harmful interference.

In addition to any protest you may make, your intruder watch should be advised of the date, time, frequency, and nature of the intrusion, along with any relevant information you may have, such as I.D., bearing, and so forth. It is my opinion that Amateurs generally have allowed the present chaotic situation regarding intruders to develop by "leaving it to the other guy" to do something about it while they chased off "up the band" looking for a clear frequency. Unless and until Amateurs as a whole are prepared to act, either through their intruder watch or personally, the situation will not improve.

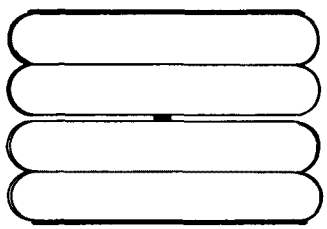
R.E. Knowles, ZL6IW/ZL1BAD
N.Z.A.R.T.
Intruder Watch Coordinator
Papakura, New Zealand

instant balun

Dear **HR:**

Here is some pleasant news, an addition to the fourth in the series of fine articles by W6GGV on transmission-line circuit design (March, 1981, *ham radio*). Last year I went through Wheeler's 1978 MTT paper (reference 1 in W6GGV's article) of constructing a 4:1 balun for the K2RIW 432 antenna. The results were pleasant indeed.

We have all seen Paul Shuch, N6TX, exploit the fact that a 0.1-inch stripline on the standard G-10 glass epoxy board with groundplane has a characteristic impedance of 50 ohms. What Wheeler's equations show is that a 0.1-inch stripline centered between two parallel plates, constructed of our G-10 boards, is also 50 ohms! (See sketch.) You'll need four one-sided boards. Etch a 0.1-inch-stripline on one using the standard tape. Etch a second board free of copper, then epoxy all four boards together. Instant balun.



A sandwich of four G-10 glass epoxy boards make an instant 50-ohm balun.

C.R. MacCluer, W8MQW
East Lansing, Michigan

ten-second call swaps

Dear **HR:**

As a newcomer to DX, I find myself dismayed when, after exchanging callsigns with a DX station, the other operator rushes off to make another contact. While I realize that he is trying to give other operators in the window a chance to make contact, I feel that these ten-second QSOs should be limited to Field Day and similar contests. It is my opinion that, in order to qualify for a DX award, the operator should acquire some minimum information regarding power, antenna, or even atmospheric conditions. This would add possibly another ten seconds to each QSO, which I don't think would be excessive or prohibitive.

Part 95 states that one of the fundamental purposes for the Amateur Radio Service is to advance radio technology. A call-swap QSO does not help to accurately evaluate a new antenna or an experimental matching network. Armed with the information I suggest to be exchanged, some reasonable judgments can be made and conclusions drawn concerning a stations performance.

I am aware that the system I propose is not perfect, and some modifications would have to be made but I can see nothing constructive or creative coming from the current DX practices, and I think that it *is time for* a change.

Bill Marinara, WB1FJE
Hamden, Connecticut

presstop

ALL 1.8-1.9 MHZ POWER LIMITS WERE LIFTED on June 10, when the Commission also reduced restrictions on the top half of the 160-meter band. The remaining restrictions, listed here by state, are:

States	1900-1925 & 1975-2000 MHz	1925-1975 MHz
ME, MA, NH, RI	100W day/25W night	no operation
CT, DE, MD, NJ, NY, PA, VT	200W day/50W night	no operation
KY, NC, OH, SC, TN, VA, WV	500W day/100W night	no operation
FL, GA, IL, IN, MI, WI	500W day/100W night	100W day/25W night
AL, AR, IA, MN, MS, MO	1000W day/200W night	200W day/50W night
All remaining states	1000W day/200W night, entire 1900-2000 kHz	

The FCC Also Warned, in its announcement of the relaxation, that new limits could be imposed at the end of 1982 at which time the WARC agreements go into effect. However, 1.8-1.9 should not be affected.

ARRL Deserves A Big Vote of thanks from all Amateurs for its leadership of the effort to restore 160 meter privileges.

PROHIBITIONS AGAINST 420-430 MHZ USE by U.S. Amateurs near the Canadian border, a change in 220-225 MHz status, and a new 902-928 MHz band are all included in the FCC's just-out General Docket 80-739. In this "Second Notice of Inquiry in the Matter of Implementation of the Final Acts of the World Administrative Radio Conference," the Commission reviews the spectrum from 28 through 1215 MHz with no changes proposed for 10, 6, or 2 meters.

However, 220-225 Is To Go from its present Radiolocation-Primary, Amateur Radio-Secondary status to one with Amateur, Fixed, and Mobile all sharing primary status. In accordance with the WARC Region 2 allocation, this would leave the door open for later FCC allocation of part of the band to one of the other services.

Operation Between 420 And 430 MHz would be forbidden to Amateurs located in a strip of the northern U.S. stretching from the Atlantic to the Pacific, to prevent interference with Canadian commercial users of that segment formally assigned worldwide for the Fixed and Mobile services at WARC. Among the Amateurs affected are those in or near such major cities as Seattle, Detroit, Toledo, Cleveland, Buffalo, and Bangor. A precise description of the area affected appears in Part 1.955 of the Commission's rules.

A New Band At 902-928 MHz is the good news, with Amateur Radio a secondary allocation to Radiolocation. The only part of the country that won't have use of this new band is in Colorado, in an area that unfortunately includes Denver.

Reply Comments on this Notice of Inquiry are due at the FCC by July 30.

ROBERT W. STANKUS (KESWICK SALES) WAS INDICTED on 22 counts of using the U.S. mails to defraud by a Federal grand jury in Roanoke, Virginia, June 10. He'd advertised new Kenwood TS-520SEs in the Ham Trader for $369.95 last fall, and though he'd even delivered a couple (purchased from legitimate dealers at near list prices), more than 50 Amateurs had eventually filed complaints with the Postal Service over his failure to deliver rigs as promised.

Eleven Of The Complaining Amateurs were selected for the indictments, with two indictments returned for each complainant. Stankus, N1AAR, was to have been arraigned July 1 and will probably go to trial this fall. If convicted, he faces a maximum fine of $1000 and five years in prison on each of the 22 counts.

PROPOSED PLAIN-LANGUAGE AMATEUR RULES, PR Docket 80-729, has received a last-minute two-month extension on the due date for Comments. Acting on a request from the ARRL, the Commissioners agreed June 15 on an August 22 due date for Comments, with Reply Comments due on or before October 21.

OSCAR 7 IS PROBABLY DEAD FOR GOOD, following a sudden failure June 12. Thermal stress induced by the solar eclipse it began experiencing on each orbit after May 22 may have triggered the failure. The current theory is that the battery pack (which had been open since a cell failed in 1978) has shorted and pulled the power bus down. KA9Q, whose calculations predicted the solar eclipse, estimates the spacecraft will return to full sunlight about July 12. There is a possibility, considered remote, that it could recover then. Users are asked to monitor OSCAR 7's beacon frequencies, 29.502 and 145.972, and to report any signs of life to AMSAT.

OSCAR 7 Has Been An Exemplary Satellite. Launched November 15, 1974, with a design life of three years, it has provided Amateurs throughout the world with literally millions of contacts during more than six and a half years of operation. OSCAR 6, with a one-year design life, lasted over four and a half years.

The Ariane Launch June 19 from French Guiana was a complete success, reinforcing expectations that the Phase 3B spacecraft will go up next year as scheduled. Two satellites, each weighing about 1500 pounds, were launched into orbit by the French rocket. One, the experimental Indian "Apple" satellite, is reported to be having problems extending its solar panels. W6VIO at the Jet Propulsion Laboratory joined WA3NAN and WA2LQQ in reporting the 1203Z launch to listening Amateurs worldwide.

John L. Reinartz
Father of Shortwave Radio

By Leonard Spencer, WA6CBQ

As a Novice-class Amateur attending one of my first radio-club meetings, I was recruited to help the guest speaker with his demonstration of a "tuna-fish-can rf bridge." It was the Monterey Bay Radio Club in Salinas, California, during September of 1959, and that speaker was John L. Reinartz. Little did I realize at the time the scope of his electronic accomplishments.

We met again when I served as president of the same club and invited him to furnish a program. He was accompanied by Mrs. Reinartz, who was a true helpmate and at that time also an Amateur with the call K6MJH. She was an observer and participant in much of the pioneer experimentation which brought about shortwave communications. It is with her cooperation that facts pertaining to these events have been obtained for this article.

Between the years 1921 and 1925, John L. Reinartz led the Amateur Radio experimenters of that time in development of shortwave communications below 200 meters wavelength. Recognized engineers and scientists of that time considered these wavelengths useless.

Reinartz engineered the receiving and transmitting circuits, developed tune-up procedures, and did the research necessary to explain how the shortwaves performed as they did. For this Amateur Radio accomplishment, he truly earned recognition as the *father of shortwave radio*. He upset many of the accepted theories of fundamental radio communications and probably for this reason did not get the recognition he deserved at that time.

greatest contribution

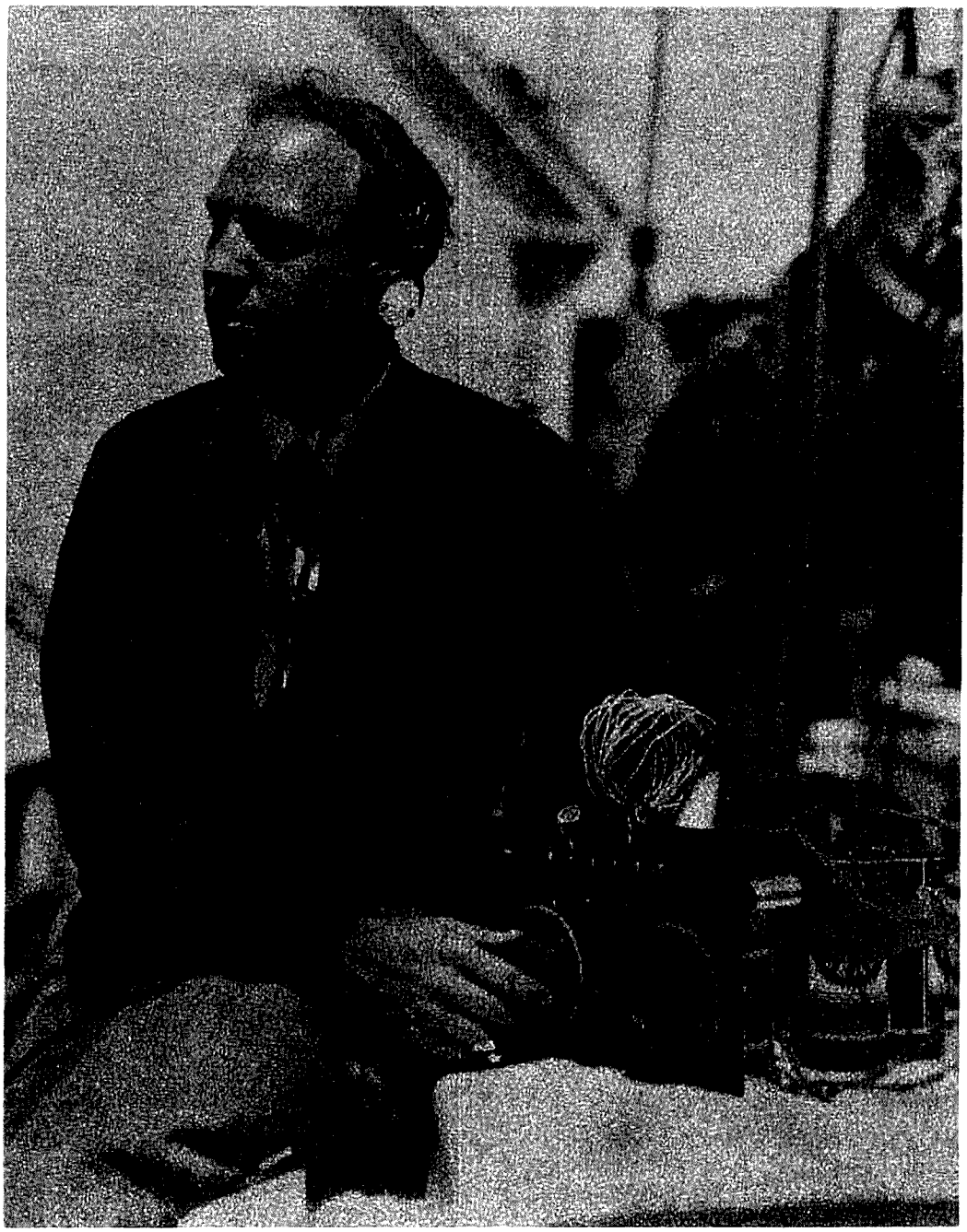
In 1964, Herbert Hoover, Jr., W6ZH, then president of the American Radio Relay League, awarded Mr. Reinartz the first Hiram Percy Maxim Gold Medal for the greatest contribution to Amateur Radio in the past 50 years. The ceremony took place on the 50th anniversary of *QST*, at the Pacific Division Convention in Sacramento, California. Actual presentation was made later at the Fort Ord Hospital, as Reinartz was unable to attend the convention.

Mr. Hoover summed up his address with this tribute to Reinartz, then retired and living in Aptos, California, and using the call K6BJ:

"In the immediate scramble for shortwaves that followed his basic concepts, Reinartz' pioneering work became strangely overlooked. Perhaps the fact that he was an obscure electrician in a New England textile mill, who had overturned the accepted theories of the scientific authorities of the day, had something to do with it.

"But John Reinartz should not be forgotten. Quiet, modest, and unassuming as he may be, he — perhaps more than any other individual — is the father of shortwave radio. When we realize that today, 40 (now 57) years later, the great bulk of the world's long distance radio communications — broadcast, point-to-point, marine, aviation and all others — still takes place on these same shortwaves that were first demonstrated by Reinartz, we can justly be proud of his Amateur accomplishment."

When Mr. Hoover's activities at that time are considered, these statements give more perspective to



Reinartz was radio operator on board Bowdoin *for MacMillan's 1925 Arctic Expedition using WNP (Wireless North Pole). Many firsts occurred that summer when shortwave radio provided daily communications from the far north in the daytime. Commander MacMillan wrote in a National Geographic story, "Much of the success of the Expedition's radio work depended upon the eager cooperation of Reinartz' associates of the American Radio Relay League in transmitting messages. More than 30,000 words of news dispatches alone were sent out from* Bowdoin *addressed to the National Geographic Society and released by it, day and night, to the press associations." All without financial remuneration — remember the regulations!*

events in early-day radio. With the call 3ZH he had a kilowatt tube-type transmitter in Washington, D.C., and during the 1922 transatlantic tests his station was heard in Switzerland and elsewhere in Europe. He was trying to communicate across the Atlantic at much the same time as Reinartz. It was the shorter wavelength 100-meter equipment used by Reinartz that made the accomplishment possible, using a 100-watt transmitter with 400 watts input. As Reinartz said in a magazine article at the time, "I didn't give a darn whether I burnt up the tubes or not."

honored as a professional engineer

More professional recognition was given Mr. Reinartz in January, 1958, when he was named a Fellow of the Institute of Radio Engineers for his early work on radio-wave propagation. He had 28 patents in the electronics field, but his early circuits were not controlled, as he wished everyone to make use of them, even to the extent of letting commercial enterprises manufacture them.

Reinartz received a bronze-plaque life membership in the Institute of Electrical and Electronics Engineers, Inc. A medal was awarded him by the Manchester, Connecticut, Chamber of Commerce on May 14, 1925. Manchester was his home town. The 1960 session of the California Legislature passed a resolution, dated March 8, commending Mr. Reinartz for his contributions to microwave radar. A beautiful plaque from the Central California Radio Council was presented to Reinartz, K6BJ, on April 6, 1960, in recognition of his many years of service to Amateur Radio. Among his other honors he was a member of the Explorers Club of New York, the American Polar Society, an original member of the American Radio Relay League, and an associate member of the Naval Institute.

spark station in 1908

John's youthful interest in radio started in 1908 when he bought an issue of *The Electrical Experimenter* at a magazine counter near school. He bought the secondary of a one-inch spark coil he saw advertised there by saving the 10 cents a day he earned working for a blacksmith. The transformer was completed by using iron wire for the core and bell wire for the primary winding. He made the electrolytic interrupter for the spark coil, and fashioned a coherer from a quarter-inch glass tube filled with filings from nickel coins. Using his initials, JL, as his call (as was done in the days before controls), he connected his spark transmitter to a 600-foot antenna installed between some trees and went on the air.

By 1921, Reinartz, using the call 1QP and working as superintendent of the local power company, published a magazine, *How to Build Receivers and Transmitters at Low Cost*. It was distributed free, and it was at this time that his famous tuner was developed. These circuits were reproduced and information on construction reprinted in the radio magazines of nearly every country in the world. Because of this wide publicity, thousands of his tuners were built.

QST in October, 1922, carried a symposium of further improvements on the Reinartz tuner. An editor's note states: "It is impossible for us to keep up with this man Reinartz. Since preparing the foregoing for publication he has dropped around with another 'trigger circuit' that knocks its predecessors cold."

first across Atlantic on 100 meters

Reinartz participated in the planning of, and designed the circuits used for transmitting, the first transatlantic two-way radio communications. Monsieur Leon Deloy, f8AB, of Nice, France, had been in the United States to attend the 1923 ARRL National Convention in Chicago. At that time, Deloy visited the Reinartz home in South Manchester, Connecticut, where he was given the circuits and construction details of the famous transmitters at a session that lasted until 3 AM. Together, they arranged for the transatlantic tests on 100 meters. Reinartz had developed a single tuner for receiving which was variable from 200 meters down to 28 meters, along with the technique of setting the transmitting and receiving equipment to precisely the desired frequencies so each station was compatible with the others.

This great event in shortwave radio took place the night before Thanksgiving Eve at exactly 10:30 EST, the time at which the restrictions on Amateurs, to prevent interference with broadcast listening, were lifted.

F.H. Schnell, a1MO, traffic manager for the ARRL in Hartford, Connecticut, had secured special permission from the Supervisor of Radio in Boston to use the 100-meter wavelength for these experiments.

Deloy, f8AB, on the night of November 27, 1923, called America and sent two messages prior to the 10:30 schedule. Both of these messages were copied by Reinartz at his home station in South Manchester.

At 10:30 long calls to France by a1XAM, the special experimental call assigned to John Reinartz, and a1MO, the call of the station owned jointly by Schnell and Kenneth B. Warner, secretary of the

ARRL, were heard "QSA vy one foot from phones," across the Atlantic. Steady and reliable communications were carried on for two hours and five minutes that night, which was until 6:35 AM in France.

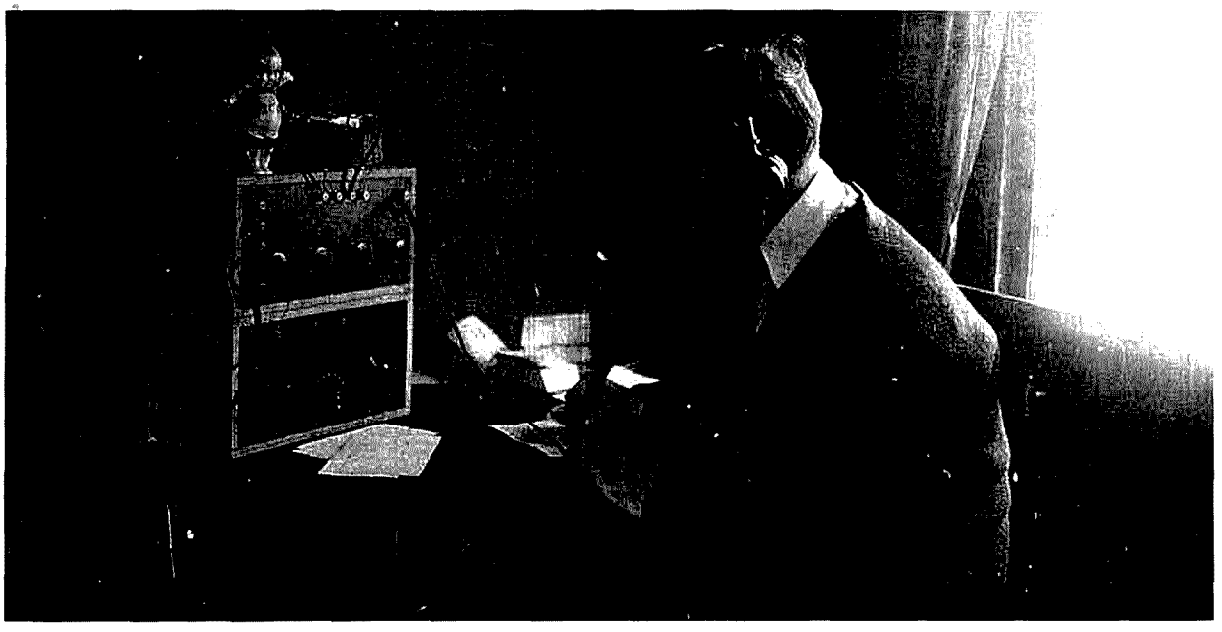
Message number one from America was addressed to General Ferrie, Director of Telegraphs for the French government, which was acknowledged at 11:06, and read as follows:

"America greets you for the first time by Amateur Radio across the ocean on 100 meters." Signed ARRL.

long-wave communications

Another sidelight to the problems of this era was that very little commercial equipment was available for use below 200 meters. Reinartz' circuits accomplished this, making the short waves practical for experimentation.

Early transmitting circuits were not shielded. They were of open breadboard construction, so rf potentials were prevalent pretty much everywhere. Reinartz seems to have been the first to establish a nodal



This operating position shows John L. Reinartz in 1921 with his famous tuner of that era in use, with three stages of audio amplification in the top cabinet. The spark transmitter, located in the cellar, was remotely controlled from this upstairs room. The Kewpie doll on top of the receiver was sent to him by a Canadian Amateur as a mascot – he had the famous 1QP call at that time and signed some of his message traffic "Kewpie."

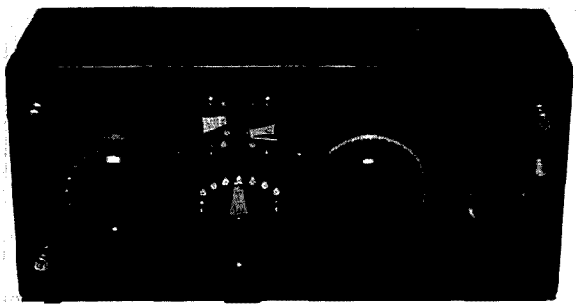
Two nights later, Reinartz' station, 1XAM, succeeded in connecting with Deloy's f8AB in France twice, and at 10:40 asked Deloy to change his wavelength as he was being interfered with by station KDKA at about 103 meters. Deloy was not heard after that.

A complication arose when international DX became possible, that of identifying call letters for the various countries. Assignment of calls specified a district by number and a suffix of alphabetical characters, but no prefix to the call. The early DX workers added prefix "u" for United States, "a" for America, or "y" for Yankee, to establish country of origin as the United States of America. Great Britain used "g" and France "f" to do the same.

point, or point of zero rf potential, at the filament tap on the oscillating circuit. He did this by connecting an rf choke from filament to ground and tuning the circuit until no current flowed through the choke. This later became part of the standard technique.

A really practical shortwave transmitting circuit designed by Reinartz was published in an Amateur Radio magazine, *The Modulator*, in May of 1923. This was the official organ of the Executive Radio Council, Second District, published in New York City.

The story was tied in with another article concerning the failure of two-way transatlantic work between the American and English Amateurs. Because of the great amount of interference, anything in the



Here is a panel view of 1922 version of the Reinartz shortwave tuner, built by W. W. "Woody" Wilson, WA6KVW, from an early magazine article. He used authentic parts of that period from his extensive antique wireless collection. Switch points picked up progressive taps on the coils — an early version of band switching, you might say.

way of continuous reception had been prevented when stations were operating between 180 and 350 meters. Most of the transmitting and receiving equipment was designed to function somewhere in that part of the spectrum.

shortwave experimentation

Following are quoted paragraphs from *The Modulator*:

". . . real shortwave transmission did not exist until the recent ARRL tests between stations 3ALN, 1HX and 1AW, in cooperation with 1QP were consummated.

"The results of these tests were of great interest to the Amateur world. They proved that *transmission on 100 meters was a practical proposition*. It was carried on for several weeks before the officials would commit themselves.

"And now, with the announcement of the Hoover Conference recommendations, we find that *we may have to transmit on those shorter waves*! The study, therefore, of a successful transmitter will be of immediate interest.

"One of the best shortwave transmitters used in the preliminary tests was that of station 1QP, John L. Reinartz, of Tuner fame, located in South Manchester, Connecticut. Reinartz developed for these tests a type of transmitting circuit which is not less remarkable than his receiving circuit. With it, he reached the low limit of 100 meters, with mighty good radiation.

"Reinartz tells us that the success of his transmitter depends on the adjusting of the counterpoise and antenna current so that there is equal amount of current flowing through both. To obtain this, both the antenna and counterpoise are tuned separately with a radiation meter, and the adjustment of the helix (coil) turns in both circuits. At this adjustment, the plate current is lowest. To further regulate the circuit, the grid condenser is adjusted so that the plate current falls no further.

"Now that the Amateur has proved his efficiency on what were considered 'useless' waves, he will have the opportunity to show what he can do on the lower ranges and limits. Here is the field — some of the pioneer work has been done — so let's get at it. The field is large in its opportunities, and if the Amateur's skill is equal to it, he will contribute many things to the science and art of communication on the shorter waves."

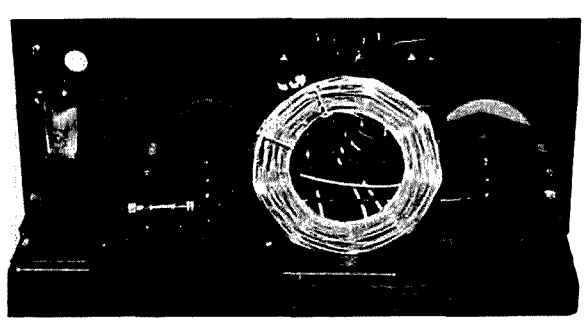
Reinartz' station on 100 meters, 1XAM, determined a new principle in antenna operation. For the first time, he used a counterpoise as the other half of a balanced antenna system instead of a capacity ground connection as had been common practice.

explains shortwave propagation

During 1923 and 1924, Reinartz compiled statistics on the stations he worked and those which reported hearing his experimental shortwave transmissions, some 5,000 in number. He hoped to determine why the shortwaves performed as they did. Experiments were carried on during an eclipse of sun to prove that sunshine made shortwave communications possible.

From his experiments, he came up with a "skip distance" theory, based on reflection or refraction from the ionized Kennelly-Heaviside layer, to explain the shortwave phenomena, and he predicted that communications would be possible across the nation in the daytime hours, which was an entirely new concept at that time.

Reinartz had schedules with stations NKF (call of Naval Research Laboratory at Bellevue, D.C.), 8XC, and 2EB on wavelengths below 40 meters in 1924. Tests were made at night, with three miles or so being the only completed QSOs.



Inside view of the Reinartz tuner with spiderweb inductance, which was an improvement over the original version in June, 1921 QST. The tube is a UV-199. Gridleak resistor was in clip holder for easy changing. Note hole in panel to check on tube filament glow, controlled by varying rheostat on front panel.

Then daylight tests were made on December 21. At 3:25 PM CST, 9EK, Hoffman, called 1XAM, Reinartz. They had been hearing each other for some time and suspected they could work together easily. This they did on 21 meters until 4:30 PM when signals suddenly dropped out. As usual with this band, darkness had changed the transmission pattern. The most important part of this QSO was that 6AJF, Frank C. Jones, at Berkeley, California, copied both stations — 9EK in Madison, Wisconsin, and 1XAM in South Manchester, Connecticut!

daytime transcontinental signals

Two-way communications on 21 meters were conducted between Reinartz, 1XAM, from South Manchester, Connecticut, and Ed N. Willis, 6TS, Santa Monica, California, at noon on January 22, 1925. They maintained continuous communications for 25 minutes and had to stop so Reinartz could get back to work as electrician at the silk mills.

The April, 1925, issue of *QST* contained "The Reflection of Short Waves," by John L. Reinartz, 1XAM, in which the editor said: "We consider this article one of the most important contributions made to radio literature." This evaluation proved to be true.

The article explains with drawings and text how the shortwaves propagated, providing the theories for the Maximum Usable Frequency and Lowest Usable Frequency as we know them today. These theories contradicted the then-accepted action of reflection by the Kennelly-Heaviside layer surrounding the earth. Reinartz' theory of "skip" is now scientific fact.

There was a controversy as to who was first to work across the Atlantic Ocean on 20 meters during daylight, but credit is given to Reinartz, u1XAM, and Secretan, g5LF, in England, for being the first to accomplish the feat.

On May 3, 1925, communication was made on 20 meters between British Amateur station g2OD and Australian a2CM, following planned experiments, so the use of shortwaves for DX rapidly became popular once the Amateurs could make the equipment work on these wavelengths. (Notice that frequency is not mentioned in the early days of radio. It was always wavelength in meters — metric units from the start!)

In 1923, Amateur Don Mix, 1TS, was assigned as radio operator with the MacMillan Expedition to the Arctic. His equipment was built to work in the 180 to 220 meter range, and this proved to be unreliable for consistent communications from the north because of the long period of daylight during the summertime. This was the eighth polar exploration of which MacMillan had been a part — and the first to use Amateur Radio to maintain contact with civilization.

Arctic expedition of 1925

John Reinartz' participation in the Navy-MacMillan Arctic Expedition of 1925 began when he received a letter from Hiram Percy Maxim, president of the ARRL, inviting him to cooperate with Commander Donald B. MacMillan, USNR, and E.F. McDonald, Jr., president of Zenith Radio, which was to supply the radio equipment. Reinartz helped to design and construct the shortwave station installed on *Bowdoin*, a schooner with an auxiliary oil-burning engine, commanded by MacMillan.

Captain McDonald, USNR, was in command of *Peary*, a coal-burning steamship, on the expedition. Lieutenant Commander Richard E. Byrd, Jr., on active duty in U.S. Navy, was in command of the Naval Aviation Detachment with the expedition in his first attempt to fly over the North Pole.

This expedition was organized under auspices of the National Geographic Society and the U.S. Navy. Here is a quotation from the *National Geographic* magazine of that time:

"Airplanes will explore in days icy areas of the Arctic which would take months to traverse by dog sleds. Radio is telling the daily program of work which in years past would be shrouded in silence for months. For the first time in Arctic history, color photographers are recording, for members in early issues of their *Geographic*, the surprising tints of the far north, the native life, birds and many beautiful Arctic flowers.

"These new aids to travel and communication enable the expedition to engage upon a program perhaps of broader exploration and scientific study than any expedition heretofore has attempted.

"The flying of the U.S. Navy airplanes under the direction of Lieutenant Commander Richard E. Byrd, Jr., and his splendid personnel, not only is epoch-making, but marks an important experiment in aviation that will focus the world's attention."

First date of the personal radio log kept by Reinartz on the Arctic expedition is June 16, 1925, while the crew was preparing to depart from Wiscasset, Maine. Amateur calls worked on 40 meters are entered in the record for several days and the *National Geographic* message of the day was transmitted using Amateur Radio for relay. Some of the interesting entries follow:

"June 26 — Left Sydney (Nova Scotia) at 9:15 AM. During radio watches, worked NKF and 1QP

(his home station in Connecticut), 1MY (a personal friend), and several other Amateurs in 40-meter band.

"June 28 — At sea bound for Battle Harbor. Gave 1MY a message by voice at 7:20 PM in the 40-meter band.

"July 1 — At Battle Harbor. Met Stanley W. Brazil who operates the northernmost Marconi radio station on Labrador coast. Made him a transmitter and receiver operated entirely from dry batteries and expected that he would be able to keep in touch with me on the trip north, which he did!

"July 2 — Don't forget to learn the code better please — I want to hear you on the air when we are up north." (This was in a letter from John to Mrs. Reinartz mailed from the last post office on the way north, Battle Harbor, Labrador.)

"July 5 — Left Battle Harbor at 12:30 AM aboard *Peary* for Hopedale (Labrador). Sailed on *Peary* in order to put their defunct radio equipment in commission. Was necessary to tear out all the radio equipment and rebuild more compactly.

"July 6 — Left *Peary* after fixing radio equipment and reboarded *Bowdoin* when she stopped on account of fog.

"July 23 — From WNP to 1MY 6 PM via f8QQ. Have Gertie (Mrs. Reinartz — Gertrude) keep 1XAM going on 20-meter band with bug 8 AM to 8 PM Saturday and Sunday. Sig. Kewpie." (This was for experiments in determining time when 20 meters would be open to the United States from the northern end of Greenland. Reinartz had an automatic code sending device at his home station, which he had used earlier in his experiments on shortwaves. The keyer was made by John from a clock mechanism and the spring had to be wound up every half hour. Code signals were made by timing from a revolving disk attached to the clock.)

"August 2 — Etah at last. Had a great time today. Heard many 20-meter Amateur stations and worked 9CXX, Cedar Rapids, Iowa, on 16 meters. Gave him message number 218 to Mrs. QP."

Quote
Am well and happy. Love via 20 meters from Etah the first time in history of radio at 3:40 PM.
Kewpie
Unquote

This message was telegraphed to Mrs. John L. Reinartz that same day by Arthur Collins, and several other Amateur stations who received it, and was the first message ever to be sent on short wavelengths from the frozen north in the daytime.

Etah, Greenland, was the ship base from which the planes explored the uncharted regions of the North Pole. WNP (Wireless North Pole) operated by Reinartz, was aboard *Bowdoin* at Etah. (9CXX was the station of Arthur A. Collins, then a student in high school. He cut classes to get back to his rig to handle these communications. He was to become famous for the manufacture of quality electronic equipment, and Collins Radio is now part of Rockwell International conglomerate.)

"August 11 — The three planes off to Ellesmere Island at 10:47 AM. The NA-3 back at 2:15 PM, the NA-2 back at 2:30 PM, and the NA-1 back at 2:44 PM. They could not land due to fog. Was in radio communication with Washington, D.C., through Cedar Rapids, Iowa, and gave notification the instant the planes returned. Newspapers had news within 15 minutes of their return.

"August 12 — It is evident that planes are not going to be useful up here. The Los Angeles (dirigible) would be much better. A drop means certain death. Looks as if the flyers knew it too well.

"August 15 — Made world's record by using radio telephone to Cedar Rapids at 12:30 PM.

"August 17 — Not much doing. Planes having hard time finding landing place on Ellesmere Island. Again talked with Cedar Rapids at 2 PM. It was noon at Cedar Rapids.

"August 18 — Same old story. Planes not suited for job." (These single engine Loening biplanes were specifically equipped with dry-battery-operated receivers and transmitters capable of operating between 37 and 42 meters wavelength, plus standard Navy aircraft equipment operating on 500 meters.)

"August 20 — Bad weather. Packing up to go home.

"August 21 — Left Etah at 6:29 AM for home.

"September 14-20 — At Godthaab (Greenland). While there visited the Norse ruins, going to the ruins on September 15 at 7 AM and returning on the 16th. The ruins are about 15 miles from Godthaab, at the end of the fjord.

"October 10 — stayed at Monhegan due to storm until Monday morning when *Bowdoin* left for Wiscasset. The end of the journey."

The next year, after the expedition of which Reinartz was a part, Lieutenant Commander Richard E. Byrd and his pilot, Floyd Bennett, flew over the North Pole in a commercial type Fokker three-motor plane, *Josephine Ford*. Bennett had been a Navy Pilot with the 1925 MacMillan Expedition. The flight left from Kings Bay, Spitsbergen, May 9, 1926, making a 15-hour, 1500-mile trip over the pole, returning to Spitsbergen.

Three days later, May 11, 1926, the Amundsen-

Ellsworth-Nobile flight, leaving from the same place, using a dirigible 347 feet long, dropped Norwegian, American, and Italian flags over the North Pole and continued on to Teller, Alaska. Each expedition added more knowledge about the Arctic region, making it easier for other explorers to follow them.

After the Arctic expedition, Reinartz did further experimentation for the Navy, and worked on measurement of voltages produced by growing plants at what is now the University of Connecticut. He was commissioned a lieutenant in the Naval Reserve in 1929 and conducted weekly classes via radio for Third Naval District personnel.

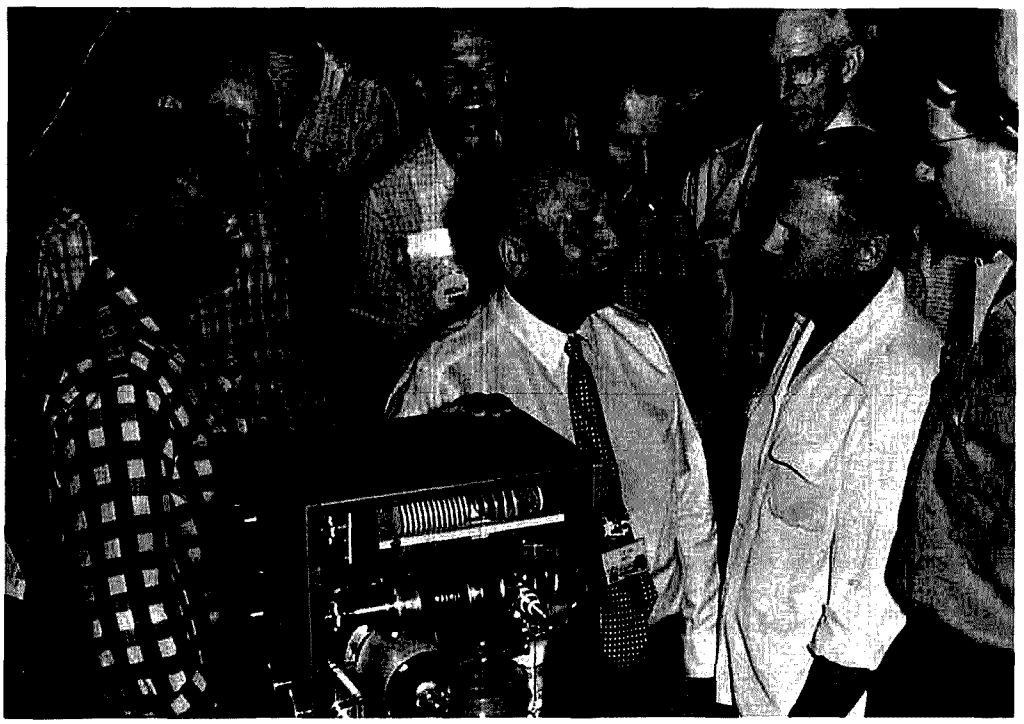
fying fm radio.

Professional engineering status was earned in the State of Connecticut, July, 1936, when he was issued Certificate of Registration number 947.

active Navy duty

In 1938, Reinartz was called to active duty in the Navy as a personnel officer, assigned to assemble eligible, experienced radio personnel for training and research. By the time of Pearl Harbor, he had assembled a list of 720 reserve officers and 3500 enlisted reserves who were quickly assigned to communications duties.

His initial job done, Reinartz was assigned to other



At the 1955 ARRL Pacific Division Convention in Fresno, California, the technical discussion topic was "Your Future One-kW SSB Final." Here John L. Reinartz shows the finished transmitter to very interested Amateurs at the conclusion of the lecture. About his work he said, "I'm not selling anything, but basically these hams are the men who eventually move into places of prominence as operators of the big commercial stations, engineers in the telephone industry, ship operators, executives in the communications field, and military signal transmission experts. They have the know-how for the important jobs."

Reinartz' formal education ended at the eighth grade level. He took correspondence courses and attended evening school classes to keep learning. In 1930, he decided on a college education. He attended Connecticut University for two years, majoring in radio and mathematics, but received a job offer from Radio Corporation of America that was too good to turn down, so went to work for RCA in 1933. Twenty-three Reinartz patents were assigned to RCA in this five-year period, some of them on methods of simpli-

Washington duties, including a tour as head of the Radio and Radar Division of the Naval Research Laboratories, at which time he supervised the work of 1200 physicists.

As a member of the Joint Chiefs of Staff communications setup, he had a lot to do with the vital nerve system which meant so much to Allied victory. He was assigned to the office of the Chief of Naval Operations.

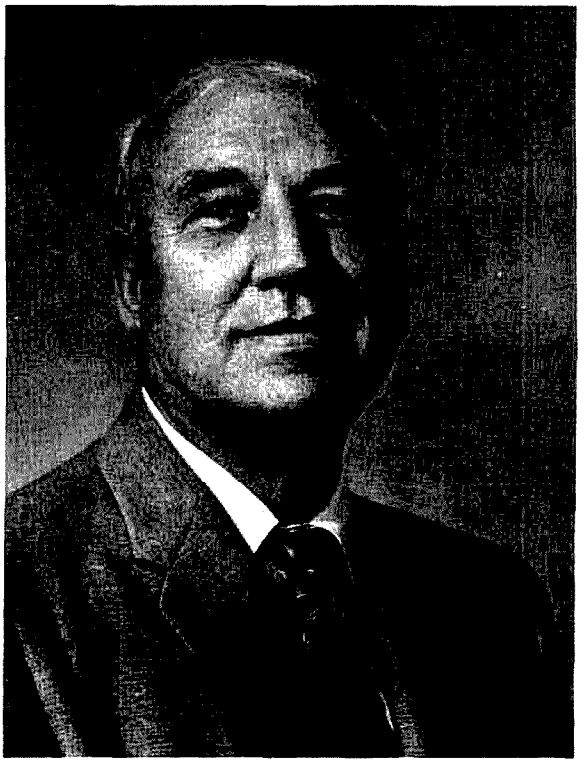
Reinartz was a member of the Defense Communi-

John L. Reinartz
Father of Shortwave Radio



Here Mrs. Reinartz points to an entry in the personal log kept by John L. Reinartz while he was radio operator of station WNP on board Bowdoin *during 1925 Arctic Expedition to North Pole regions. Captain Reinartz is in photograph beside replica of 1922 version of his famous tuner. Scrapbook behind photo is of Arctic trip and larger book contains clippings and programs of events in which John participated while with the EIMAC firm.*

This portrait was taken while Reinartz worked for EIMAC. Shortly after World War II, many photos showed him in his Captain's uniform in advance publicity of his many tours thoughout the United States, giving lectures and demonstrations before professional engineering, Amateur Radio, and public services groups.



cations Board at its formative meeting January 6, 1941. For a time, he was on the West Coast in charge of modification of all airborne radar for the Pacific areas.

In 1946, Reinartz rejoined RCA, and in 1949 moved west to become part of the Eitel-McCullough, Inc., organization at San Bruno, California, in a similar capacity, as field engineer and manager of the Amateur Radio Service Department, until retirement January 30, 1960. (The Eimac transmitting-tube manufacturing firm was founded in 1934 by two Amateurs, W.W. "Bill" Eitel, W6UF, and Jack A. McCullough, W6CHE.)

honored in retirement

His retirement prompted a John Reinartz Testimonial Amateur Radio Banquet February 1, 1960, in San Mateo, California. Seventeen speakers praised John for his pioneer accomplishments in the field of electronics. Two hundred invited guests paid him tribute by their attendance at the banquet, almost all of them with Amateur Radio calls.

Check your QSL cards to see if you have worked John L. Reinartz on the air. Calls he held and used were JL, 1QP, 1XT (a special land station call issued by Bureau of Navigation, U.S. Department of Commerce), 1XAM (special shortwave experimentation call), NDF, WNP, N1QP, W3RB, W3IBS, and K6BJ. The Santa Cruz County Amateur Radio Club now uses the K6BJ call for its John L. Reinartz Memorial Station in the Santa Cruz, California, area, so listen for it Field Day, and work it.

This quotation comes from an interview with John Reinartz published in the Augusta, Georgia, *Chronicle* of Thursday, May 3, 1956:

" 'It's a wonderful hobby — radio,' he says. 'I can't recommend it too highly. A normal lad can build himself a receiver for as little as $10 — and a transmitter for only $25. If he uses the right frequencies he can cover a good part of the world with such a rig. And experience in radio can stand him in mighty good stead in this Atomic Age.' "

ham radio

an analysis of ALC circuits

Automatic load control circuits are investigated as a means for avoiding distortion in SSB transmitters

This article dispels the mystery of the ALC circuit used in Amateur SSB transmitters and addresses problems encountered when using linear amplifiers made by one manufacturer with exciters made by another manufacturer. Such problems include splatter, which may occur even though the ALC line is connected between the two pieces of equipment.

ALC defined

ALC is an acronym for *automatic load control* when used with SSB transmitters. The term goes back to the days when Bell Labs made a high-frequency SSB transmitter whose output was in four channels. The term *loading* in telephone work indicated the number of channels in a multichannel system that were in use at any given time. Their automatic load control kept the peak envelope power from the SSB transmitter about the same, regardless of whether only one or all four channels were in use. Probably there would be less confusion as to the function of automatic load control if it had meant automatic level control.* Even automatic gain control might be appropriate, except for the fact that it would be confused with the system used in receivers.

So in terms of today's technology, what is ALC? What does it do? Why use it? These questions are explored in this article, which includes a discussion of the principles of ALC and why, if used properly, it helps to eliminate interference on the Amateur bands by reducing spurious products in SSB transmitters.

some background information

In a-m communications systems it was common to use speech compressors and clippers, so that the power amplifier could operate near its maximum power-output capability without excessive distortion products. As used in single-sideband, ALC is part of a system that is intended to maintain the distortion products of a *linear* amplifier within acceptable limits.

ALC may be thought of as an rf compressor. You might ask, Why not use audio compression to hold

*To add to the confusion, automatic level control has been used in Broadcast engineering to define a method for taming speech amplifiers. **Editor**

My thanks to Professor Charles Gould, W4LZO, for reviewing this manuscript – John P. Weber.

By John P. Weber, Jr., K4JW, 102 Southgate Boulevard, Melbourne, Florida 32901

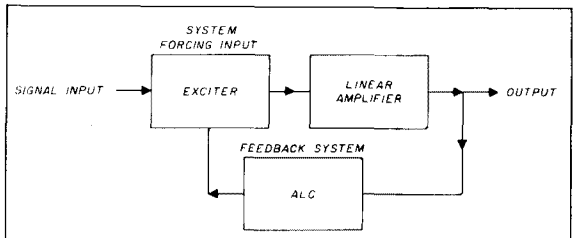


fig. 1. Block diagram of linear-amplifier control system. The device being acted upon is the linear amplifier; the stimulus, or system-forcing function is from the exciter. Thus a control-system feedback loop is formed, which prevents the amplifier from being overdriven and producing distortion products on audio peaks.

the transmitter output to an acceptable maximum? Well, the peak levels of the SSB signal don't always correspond to those of the audio signal. So the method referred to as ALC in SSB controls the drive power from the exciter (input to the linear amplifier) by sampling the rf output of the linear amplifier, rectifying this output signal to obtain an audio signal, and feeding the filtered dc back to a stage in the exciter that controls the exciter's gain. It is similar in operation to the AGC circuit in a receiver.

The point is that we are trying to maintain a *linear* input-output relationship for the amplifier over the range we're using. Of course, if the linear amplifier could maintain its linearity over the desired operating range by its design, ALC would not be needed. But in today's world, it's possible to overdrive the linear amplifier, which creates splatter.

Now if you don't care about your signal quality or what you're doing to the hams 7 kHz away, stop here! When contacting manufacturers for technical information, an engineer at one company replied, "It is our considered opinion that most DXers do not use the ALC feature inasmuch as they wish to obtain maximum power output, splatter or no splatter." While I don't think it applies only to DXers, this gentleman's observation is borne out by listening on the Amateur phone bands. I'm interested in the ham who has his ALC line hooked up and is *still* splattering.

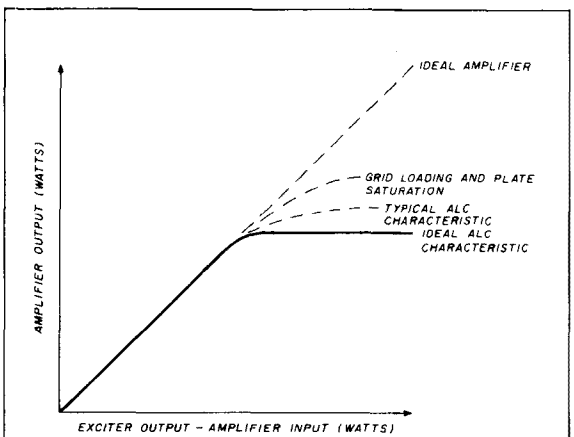


fig. 2. Amplifier transfer function, showing the relationship between linear and nonlinear characteristics; the latter caused by plate saturation and grid loading.

analysis

For a thorough discussion of linear distortion mechanisms and measurements, I refer you to the article by Warren B. Bruene;[1] this is must reading. References 2, 3, and 4 are excellent material, not only on ALC circuits, but on all facets of SSB. They may not, however, be easy to obtain.

Fig. 1 is a block diagram of a basic ALC system, from the standpoint of control-system design. The device being acted upon is the *linear amplifier*; the stimulus, or system-forcing input, is the exciter. The linear amplifier has a transfer characteristic; that is, its output related to its input stimulus. If we sample the amplifier output, process it, feed it back to control the stimulus (or exciter), we have a closed-loop control system. Why this roundabout approach? I've found that some hams get confused if I use the term *feedback*, relating it only to an audio amplifier; but they seem to understand the control system concept.

What we are trying to accomplish is shown in the curves of **fig. 2**. We see the ideal linear transfer characteristic that is linear over the entire range, regardless of the input. Then we see a nonlinear condition occur as we go over a certain value of input. In a practical grounded-grid SSB vacuum-tube linear amplifier, this is usually the result of two effects:

1. *Plate voltage saturation* — the output of the tubes tries to exceed twice the value of the supply voltage.

2. *Grid loading* — as the grids begin to draw current, they present a varying load to the exciter, and because of the exciter's regulation, the exciter will drop its output, generate harmonics, and the power output from the linear will decrease.

Ideally, we want to cut the output power at a point where further exciter drive will not result in additional amplifier output that is distorted. Our compressor would have a curve that suddenly flattens off at the threshold point; but practically, we will get some further increase in output, as shown.

basic circuit

A basic ALC circuit is shown in **fig. 3**. The output rf voltage of the amplifier is sampled, divided by a capacitive divider consisting of C1 and C2, rectified by diode CR1, and fed into a filter consisting of R1, C3,

and R2. This ALC voltage is fed *into* the exciter.

Most modern exciters have an *internal* ALC system that works from the exciter's output stage back into earlier stages to control its linearity. We can take the ALC from the power linear amplifier and feed it into the internal loop of the exciter to reduce its output to prevent overdrive of the linear amplifier.

In the case of this simple form of ALC system, the threshold point at which ALC action starts is determined by the exciter's ALC circuitry. Many times, this takes the form of a zener or biased diode arrangement. Since the exciter controls the point where the threshold is, how do we know we have the right voltage from the linear amplifier to initiate this action? If both designs were by the same person, he could ensure that these points coincide. But, if the linear amplifier comes from one company and the exciter from

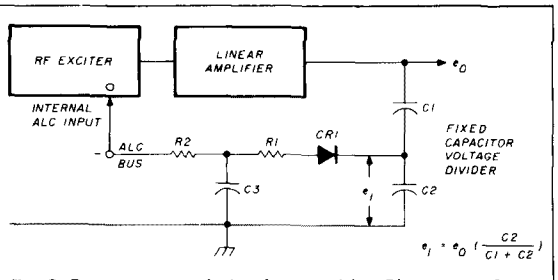


fig. 3. Basic automatic load control (ALC) system. Amplifier output rf voltage is sampled, divided by a capacitive divider, rectified, and filtered. This voltage is then fed to the exciter. Compatibility between exciter and amplifier is necessary for effective control of the amplifier.

another, how can we assume that the ALC action is optimum, or even exists?

examples of ALC circuits

Now let's look at some circuits. The sampling was from 24 models made by nine manufacturers. Examining **fig. 4** we see the first step above the basic circuit. In **fig. 4-A**, again we have the capacitive voltage divider, this time across the cathode or input circuit of the grounded-grid linear amplifier. Why sample the cathode rf voltage? Well, the power gain of the tube or tubes is very nearly equal to the ratio of rf plate voltage to the rf cathode voltage, since the tubes' plate current is common to both the input and output circuit. Actually, it's a little different because of the power absorbed by the grid(s) and input- and output-circuit losses; but it is a convenient low-voltage point in which to work. This divided voltage is rectified by CR1, filtered by R1, C1, and R2, then fed to the high side of a pot, R3. This pot enables adjustment of the output voltage (ALC) to match the requirements of the particular exciter with which it's being used. However, the threshold is still controlled by the exciter's internal circuitry.

the most common ALC circuit

Fig. 4B shows the most common ALC circuit in use, according to my study of manufacturers' diagrams and also from knowing which are the most popular units by on-the-air listening.

The components are *all* established by *the designer* and probably are intended for use with exciters manufactured by his company — remember, he has extensive knowledge of the exciter.

Again, a capacitive divider is in the cathode circuit; a diode is used to rectify this rf voltage. However the diode is biased so that it will not conduct — this bias is usually derived from a resistor tap in the high-voltage supply bleeder circuit; or, in some cases, from a separate low-voltage power supply that is used to energize relays and pilot lights.

Since the diode is biased, no ALC voltage appears from the linear amplifier until the amplifier reaches a power level where this bias is overcome and the diode conducts.

In effect, the designer has set the threshold point in the linear amplifier. But if that point is below the required threshold voltage needed by your exciter's ALC bus, no ALC action will occur until you overdrive the linear sufficiently to start ALC action. The older exciters needed −2.0 to −4.0 volts for threshold; some of the newer ones need −6.0 to −10.0 volts. For ultra-conservatives, who are safety conscious, examine this circuit in terms of the bleeder resistor tap-to-ground opening up!

biased diode, variable threshold circuit

Fig. 4C is a circuit that allows you to overcome the restrictions mentioned above. Simply stated, the threshold point is made variable by using a pot to set the diode bias. If you note the curves shown beside each circuit, it becomes apparent that the most flexibility to work with different exciters is afforded by this circuit.

This convenience is negated, however, if the ALC control is put inside the linear or on its back panel. The control should be placed on the front panel of the linear — it is an operating control. Why? Well, first (and please don't laugh), so you can set the linear to 1 kW legal limit while in the CW-TUNE position. Second, as we've been discussing, different exciters require different values of ALC voltage. Third, the ALC setting can vary from band to band, the extent depending on its gain variation. Fourth, the input impedance of the linear can vary from band to band, changing the loading on the exciter.

The input impedance of a grounded-grid amplifier is a function of the tube design and the plate load impedance presented to the tube. This plate load impedance is determined by the characteristic of the load (antenna plus line) and how the output network is tuned. (Is loading accomplished by plate current tuned for dip or for maximum output?) Unfortunately, only one currently available unit (two-piece) has this facility; an older unit is no longer in production, and a yet-to-be-proved unit has just appeared on the market.

ALC using grid and plate detection

A unique circuit bears discussion and is shown in **fig. 5**. Unfortunately, to the best of my knowledge, it was never exported to this country. This circuit is unique in that it samples both the grid and plate signals of the amplifier. The detector connected to the grid circuit senses the pulses of grid current when the grid is driven into the positive voltage region. This voltage is doubled and fed along with the sensed plate signal to the ALC bus. A balance between these signals can be achieved by individual pot settings. The thing about this circuit that struck me was the similarity to the method of measuring linearity described by Bruene in 1954. His linearity tracer sampled the input and output of the amplifier and portrayed them on a scope; why not use them to generate an error signal for the ALC function?

time constants

The discussion above has dealt with static operating conditions: measurements made on a point-by-point basis. The amplifier, however, is operated in a dynamic condition with the stimulus being voice excitation. Now we must deal with additional considerations — the transient behavior of the system. First, there's attack time; the time for the ALC system to respond to the stimulus, or voice peaks. If this attack time is too long, the system will overshoot and "buckshot" will result. Second, the release time must be considered; this is how long it takes the ALC system to recover or return to normal gain. If release time is too long, the amplifier gain is unnecessarily reduced, especially after a loud blast into the microphone — it can result in an unpleasant pumping effect if too short.

what can be done

I've painted a gloomy picture for those who don't

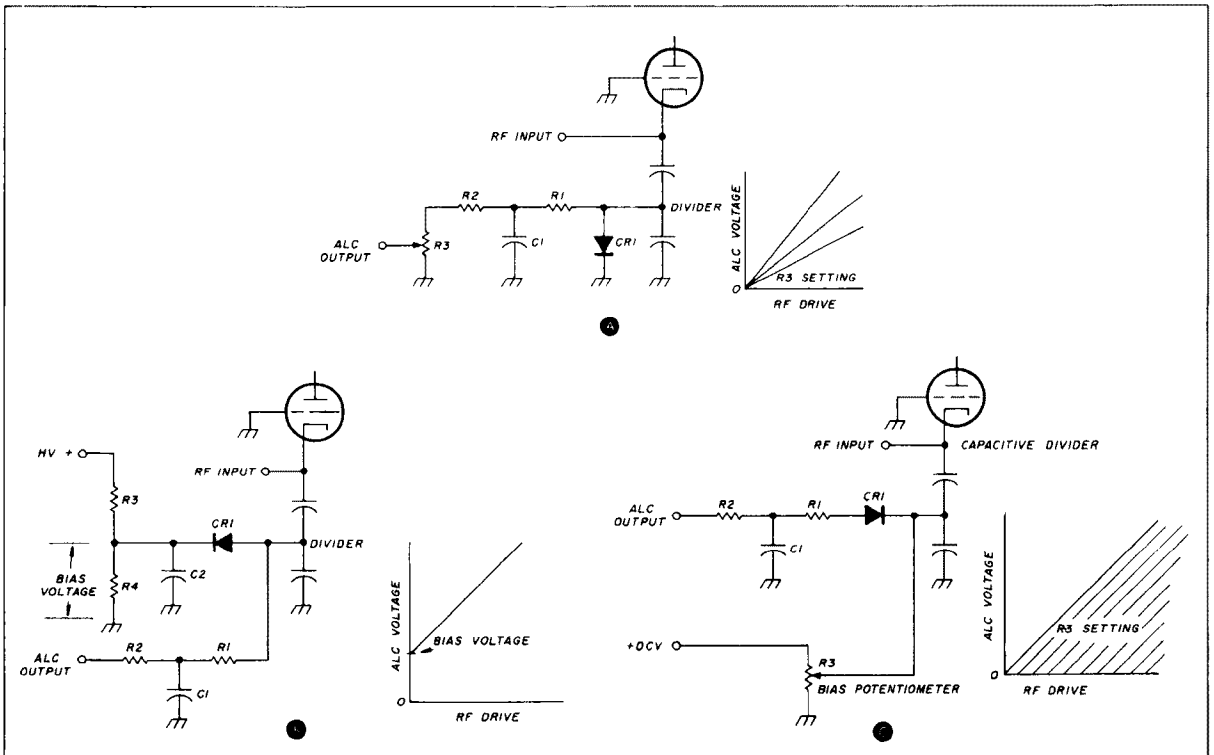


fig. 4. Examples of practical ALC circuits. Circuit at (A) is a simple system with no threshold and is adjustable by potentiometer R3. The most common ALC circuit is shown in (B), a system using a biased diode to determine the threshold point at which ALC action begins. In (C), the threshold point is made variable by using the potentiometer (R3) to set the bias to the diode.

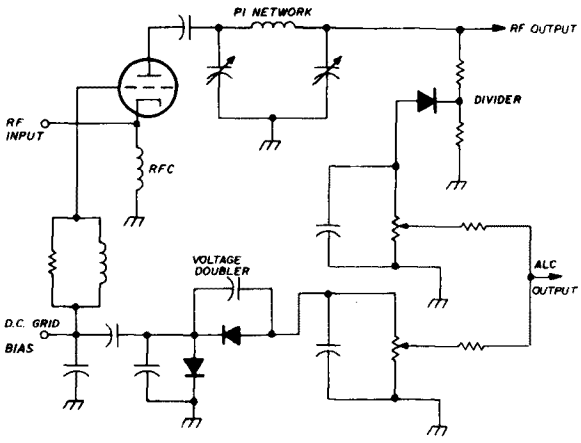


fig. 5. A unique ALC circuit using both grid and piste detection. When the grid is driven into the positive-voltage region, this voltage is doubled and fed together with the sensed plate signal to the ALC bus. The two voltages are balanced by individual potentiometer settings.

know the characteristics of their exciter or linear ALC systems — don't feel bad, neither do I! For those who say, "I watch my grid-current meter and keep the gain down until the meter just kicks," I ask, Do you know the ballistic characteristics of your meter? For those who say, "I watch my monitor scope pattern for signs of flat-topping," I ask, Do you know how much distortion is represented by how much flattening on the small pattern as it moves across the screen?

I think the same applies to those who use a trapezoidal scope pattern, although I feel it gives a fair indication of linearity. The correct method is to use a spectrum analyzer for a monitor; but I can neither afford one nor do I want to stare at scope patterns while I am talking!

If you're beginning to have reservations about using your 10-year old linear with your new exciter, or vice-versa, with ALC incompatibility problems, why not compare the manufacturer's specs on the ALC system constants? Can't find them? Neither can I!

What's needed is standardization in the industry — ALC voltage polarity, magnitude, intended load impedance, attack and release times. Having sat in on many industry standardization committee meetings, I can't give you much hope that this will happen. If military procurement or industrial safety requirements prevailed, it might happen. I don't find anything in FCC type-acceptance procedures that will help. As a matter of fact, examining one such submittal I find no mention of ALC connection, and the harmonic analysis was run with single, rather than two-tone, input and at a 50-watt input level!

Perhaps manufacturers will publish the ALC characteristics of their current and older models; it sure would be helpful. In the meantime, you can measure the voltage required to decrease your exciter's output by using a variable low-voltage dc supply, or batteries and a pot. You can a) measure your amplifier's ALC capability by terminating its ALC output with a resistor equal to your estimate of your exciter's ALC input impedance, b) excite the linear with a two-tone generator into the exciter with the linear amplifier terminated by a dummy load, and, c) measure the ALC voltage available (beware of meter loading) at the point where nonlinearity of the trapezoid scope pattern begins. At least you'll know if you need more or less ALC voltage from the linear amplifier. If you're lucky enough to have too much ALC voltage, you can add a pot on the front panel (or in a separate but accessible box) and attenuate the ALC voltage until you obtain the desired results.

final remarks

The problems of connecting ALC circuits in equipment of different manufacture have been discussed. Perhaps we can get more comprehensive data from the equipment manufacturers to assist us in properly interfacing our equipment. Consider measuring your equipment's ALC characteristics, putting a threshold control where you can get at it, and using a monitor scope. And remember, when you have that speech processor working full bore and your ALC line disconnected, you are *not* making many friends a few kHz up or down the band.

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ham radio

a new look at dip meters

Some updated versions of that most useful tool — the grid-dip meter

One of the most useful accessories in the Amateur station is the grid-dip oscillator, grid-dip meter, or just plain dip meter. It can help solve many problems associated with resonant circuits. With proper calibration the dip meter can be used to determine the frequency of resonant circuits and, with capacitors and inductors of known values, it can be used to measure unknown inductances and capacitances. VHF parasitic oscillations can be detected in rf amplifiers, and antennas and transmission lines can be checked for resonance if proper precautions are used to determine harmonic responses with respect to fundamental resonant frequency.

The original grid-dip meter used a tube-type, class-C oscillator with a meter in its grid circuit. An external resonant circuit coupled to the oscillator's tank caused a decrease, or dip, in grid current; hence the name of the instrument. If this external circuit was a high-*Q* tuned circuit, the dip in grid *current* was noticed at a rather sharply defined frequency as the oscillator was tuned. It is precisely because the grid-cathode diode of the tube rectifies rf voltage that the oscillator operates in a stable class-C mode; and this rectified rf provides the dc grid current to operate a conventional dc current meter. A typical grid-dip meter is shown in **fig. 1**.

Historically, the oldest Amateur reference to grid-dip oscillators was that made by Bud Bane, W6WB, in the March, 1947, issue of *CQ* magazine. W6WB's meter used a 3A5 for battery operation, and covered 80 through 10 meters with three coils. Still earlier use of the grid-dip oscillator is discussed in the "Zero

By Hank Olson, W6GXN, P. O. Box 339, Menlo Park, California 94025

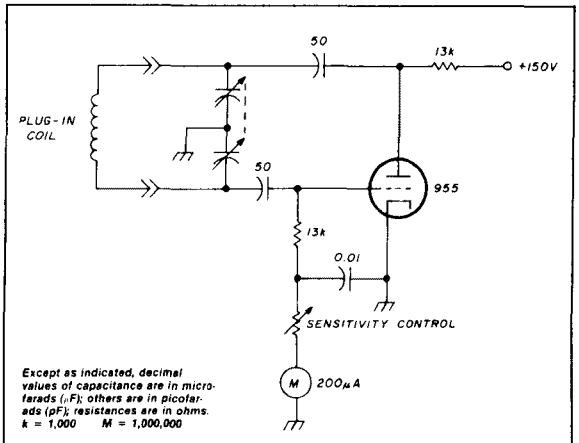


fig. 1. Basic grid-dip meter using a triode vacuum-tube (9002 and 6C4 also commonly used).

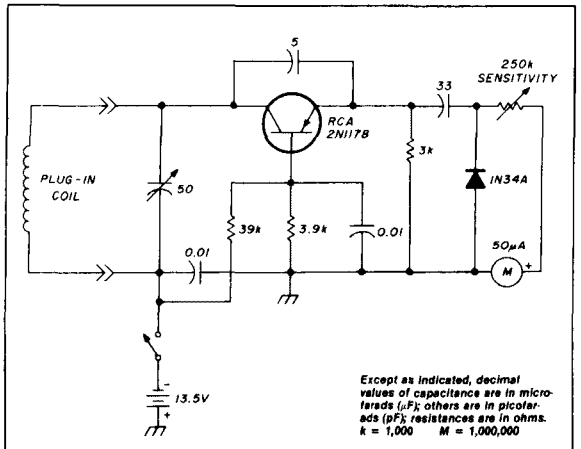


fig. 2. Typical dip meter using germanium PNP bipolar transistor with separate diode detector.

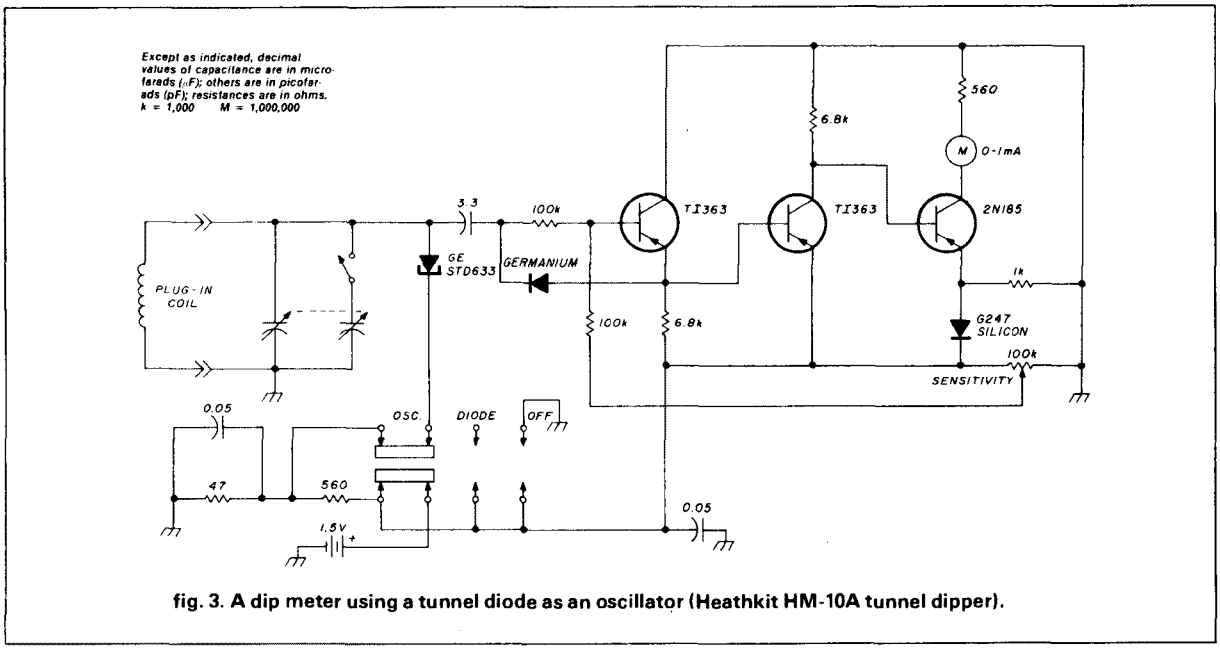


fig. 3. A dip meter using a tunnel diode as an oscillator (Heathkit HM-10A tunnel dipper).

Bias" column of *CQ*, April, 1979, and in "Our Readers Say," *CQ*, October, 1979.

When bipolar transistors became available, they were almost immediately applied as the active elements in rf oscillators — and also applied in dip meters. The term *grid-dip* had to be shortened to *dip* since, of course, there are no grids in bipolar transistors. The bipolar transistor (whether NPN or PNP) is unlike the tube in a number of ways. The bipolar transistor is a current-operated device; that is, it requires base current to control collector current. This generally means that it is a lower impedance active device, and that the base has dc current flowing in it whether oscillation is present or not. Even though the base-emitter junction of a bipolar transistor is a diode, the base current is not a very sensitive indicator of oscillation level because a good portion of the base current is dc bias current.

So we find, that, although a number of dip meters have been built using bipolar transistors, all of them make use of a separate diode detector to provide dc current for the meter.[1,2] Most of these circuits use a 1N34A or some other germanium point-contact diode as the diode detector, and might be updated by use of one of the newer (silicon) Schottky diodes. A typical bipolar dip meter is shown in fig. 2.

It is even possible (and one was commercially built by Heathkit for a time) to use a two-terminal form of oscillator: a tunnel-diode. In the Heath HM-10A Tunnel Dipper, a tunnel-diode was used as the oscillator and a standard diode detector was used as the rf detector to provide dc meter current. The Tunnel-Dipper is shown in **fig. 3** (reprinting is by permission of the Heath Company).

junction field effect transistors

The junction field effect transistor (JFET) is the first solid-state device to come along that really behaves in a "dip-meter" circuit the way tubes used to behave. Like a tube, the JFET requires voltage on the gate (grid) to control current in the drain (plate), and the gate-source junction operates like a "grid-leak" diode. So, with a lower supply voltage, an N-channel JFET can be put in an old tube-type dip-meter circuit and it will usually work immediately.[3] Early silicon JFETs had rather limited performance at VHF, and it was not until the arrival of the TIS34/2N3823 (Texas Instruments) that a good, cheap, silicon JFET was available for Amateur dip-meter construction. Subsequently, the Motorola MPF102, Union-Carbide 2N4416, Siliconix 2N5197, and other excellent N-channel, silicon JFETs became available inexpensively; these too fit dip-meter service quite well. An example of a dip-meter using an N-channel JFET is shown in **fig. 4.**[4]

the MOSFET

The MOSFET, unlike the JFET, does not have an inherent gate-source diode, and there are many MOSFETs that operate very well up through the VHF range. RCA and Motorola have a number of N-channel (depletion mode) MOSFETs that were designed for TV tuner service and are therefore inexpensive enough for Amateur dip-meter service. The 3N128 is a favorite in Amateur designs, and has been incorporated into at least one dip-meter design (see **fig. 5**).[5] Since there is no gate-source diode in a MOSFET, rectification of the rf is accomplished by adding a diode. It is even feasible to use one of the dual-gate MOSFETs, using the No. 2 gate as an oscillation level control (see **fig. 6**).[6]

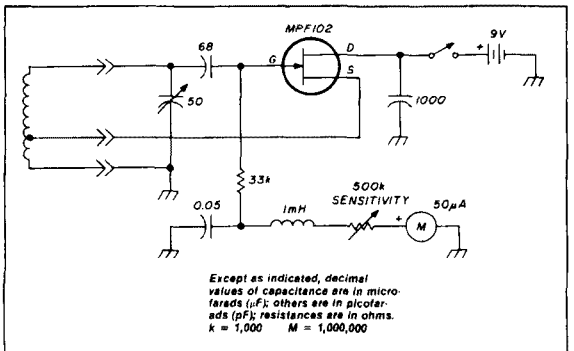


fig. 4. Dip meter using silicon junction FET.

Note that in **figs. 1** through **6** some of the oscillators use the Colpitts configuration and some use the Hartley circuit. Either form of oscillator will work, or any other form will do, as demonstrated in **fig. 3**. The Colpitts circuit has the advantage over the Hartley that only two leads must be provided for the plug-in coils.

It is possible to build a dip meter without plug-in coils. This has the advantage that the accessory coils don't get misplaced. One author has written at least two articles on bandswitching dip meters.[7,8] In reference 8, Fred Brown adds two worthwhile innovations to dip-meter technology: 1) a broadband 50-ohm output for driving a frequency counter, and 2) a square-wave modulation system which amplitude modulates at 1 kHz without fm.

With frequency counters now available for less than $200.00 that cover the range 0 to 1000 MHz, the

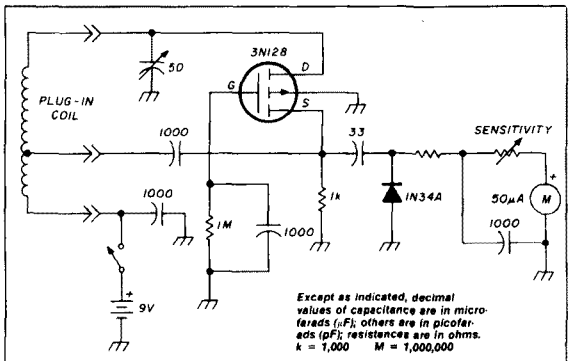


fig. 5. Dip meter using N-channel IG FET (MOSFET) and separate diode detector.

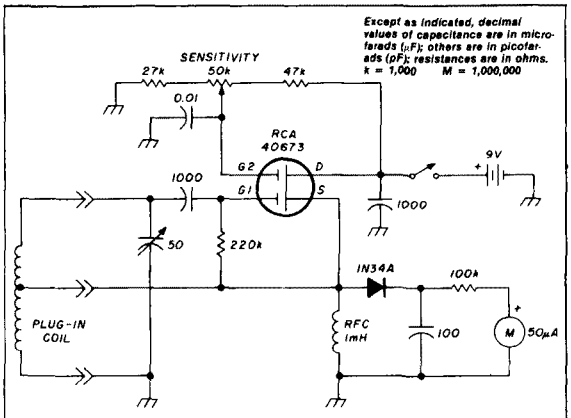


fig. 6. Dip meter using dual-gate IG FET (MOSFET) where No. 2 gate is used to adjust oscillation level.

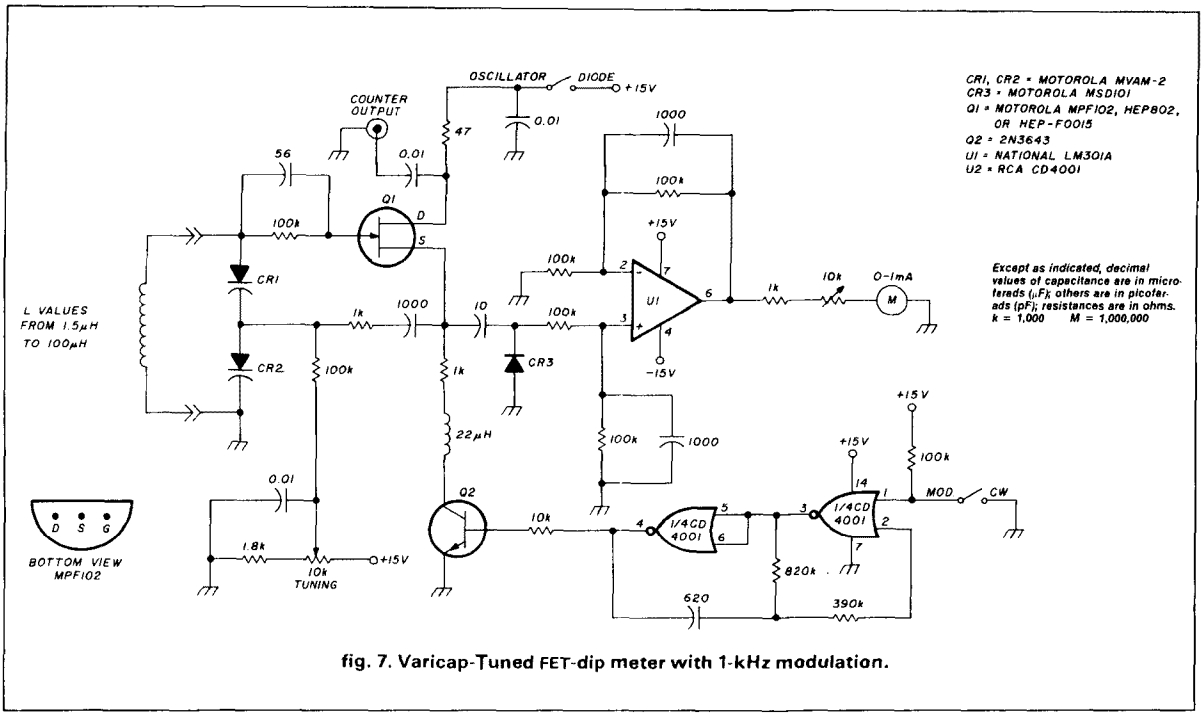


fig. 7. Varicap-Tuned FET-dip meter with 1-kHz modulation.

time is perhaps right to dispense with the calibration dial on the modern dip meter. Once this step has been taken, it is only a logical, short jump to replace the tuning capacitor with varicaps and use a remote dc pot to tune the dip oscillator, since no calibration scales are now needed. If the counter is not desired, the dc pot can be calibrated just as well as could the traditional tuning capacitor dial.

One tempting way to combine voltage-tuning the dip meter and using a frequency counter as a readout would be a microcomputer-controlled dipper. The oscillator varicap input would be a ramp (sawtooth) generated by the microprocessor; the detected dc output of the oscillator would be A to D converted and fed to the microprocessor. The program would sense a point of minimum detection voltage (where the dc slope changes from negative-going to positive-going) and remember the frequency counter digital reading at that point. This system could then simply be placed near the resonant circuit to be measured and the frequency would be read out digitally. The details of oscillator design, programming, integration with a frequency-counter, and provision for multiple dips could be a big development job; but it's certainly a system that seems feasible.

a simple dip meter

As a simple example of how one might build up a voltage-tuned, counter read-out dip meter, the circuit of **fig. 7** is shown. It was built to accept plug-in coils with banana-pins with 3/4 inch spacing; the coils were borrowed for this breadboard circuit from an old tube-type grid-dip meter.

As shown, the circuit operates over the 2-32 MHz range with each coil covering about an octave of frequency. It would probably be worthwhile to have coil units made up with three terminals, so that varicaps are changed with the plug-in coil, to allow for lower minimum capacitance at the higher frequencies, a 2N5197 or other similar VHF FET might also improve things above 32 MHz.

Look at the circuit of **fig. 7**. The 1-kHz square-wave oscillator has been redesigned around a CMOS IC, and the meter's dc amplifier redesigned around an LM301A op amp IC.

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ham radio

ham radio TECHNIQUES

Bill Orr W6SAI

The first contact on the air. The first DX contact. The first QSL card. Every Radio Amateur remembers these outstanding events long after other early memories of ham radio are blurred. Sometimes one particular event stands out in the memory, signaling a turn of fortune, a change in the pattern of life — or even a turn in history.

For thousands of Amateurs, the following story is typical of what might have happened some years ago on a date "that will live in infamy."

the greatest DXer in the world

The streetcar gave a long wheeze, as if it were dying, and slowly ground to a halt at the corner. The accordian door creaked open and I jumped out, to be greeted by a swirl of dust and dead leaves stirred up by the ancient vehicle. With a clang of the bell it slowly resumed its journey down the cobblestone street.

Dodging a new Pierce-Arrow, I reached the curb and headed down a sidestreet. I could see Pendergast's house ahead and noted that he'd put up a brand-new Zepp antenna. It ran from the high chimney over to a tree in the back yard. The new copper wires gleamed in the winter sun.

I hadn't seen my friend for over a year. We had both been away at college, and this was the first time we both found ourselves home together. I knew from the few quick notes I'd received from him that he was working on a new DX-type transmitter. Now, he'd gotten home a few days ahead of me and possibly was already on the air.

I hastened my steps and trotted up the gravel walk. It was only a few steps to the wooden porch, which looked cold and empty. The summer lawn swing and folding chairs had long ago been put away for the winter and the storm windows were already up, even though the weather had been unusually warm for early winter.

Through the glass door I saw Pendergast's sister. She was sitting on the davenport, listening to a symphony on the radio. She was wearing an angora sweater, plaid skirt, bobby sox, and white loafers. I thought to myself, "Little sister is growing up."

"Hi, Miriam, long time no see," I said as she answered the door.

Miriam was going to be a knockout in a few years, I mentally noted. It would be fun to date the sister of a fellow Radio Amateur.

After a few pleasantries, Miriam motioned for me to go upstairs to the radio room, and she returned to the symphony, curling up once again on the davenport.

"Come on up," yelled Pendergast from the rear bedroom. I bounded up the stairs, two at a time, and saw my friend. He looked quite a bit older and had grown a mustache. He had on a white sweater with a big letter *C* on it. He looked very collegiate.

"Good to see you," said Pendergast, shaking my hand warmly. "Come into the shack and bring me up to date . . . and, incidentally, look at my new DX rock crusher."

I followed Pendergast into what had once been his bedroom. How things had changed! Gone was the push-pull 210 TNT oscillator on 40 meters. Gone was the National SW-3. Down from the wall were all of Pendergast's cherished QSL cards from the stations he had worked while he was in high school. The wall was blank now.

Replacing all of the old gear was a brand-new National HRO receiver on the operating table and a new, gleaming transmitter sitting to one side on a small table. And there was a chromium-plated bug key on the table next to the receiver.

"You look older," said Pendergast, giving me a penetrating glance.

"I feel older," I replied. "That damned course in Descriptive Geometry last semester nearly finished me off. I pulled a *D* in it."

"I don't know why we have to study that stuff for an Electrical Engineering degree," Pendergast said. "Anyway, I'm *running a good B-plus* average so I can't complain."

Pendergast sat down in his operating chair and sighed.

"Is the transmitter ready to play?" I asked.

Pendergast smiled. "Yep," he said. "And 20 meters seems to be pretty good. I heard Guam this morning. Boy, could I use a KB6!"

"You have plenty of room on the wall for DX QSLs," I noted. "Now, suppose you tell me about this transmitter. It looks beautiful."

"Doesn't it?" said Pendergast. "I've worked on it night and day for

two weeks to get it going in time for this vacation. Here's the circuit." (See fig. 1.) He handed me a large, white sheet with a carefully drawn schematic on it.

"Watch my lips as I explain everything and you'll understand all," he joked.

My friend flipped a switch and the filaments of the transmitting tubes lit up.

"O.K. Now, over here is a 6F6 metal-tube crystal oscillator on 7199.75 kilocycles. I am using a variable crystal so I can QSY from 14,390 to about 14,405 kilocycles."

"Plenty of DX to work outside the band edge," I remarked.

"No, no!" said Pendergast. "I have the band edge marked on the knob of the crystal with ink. No problem, there. Anyway, after the oscillator stage I have an 807 doubler to 20 meters."

"Were you able to tame the 807? It's a tricky tube," I remarked doubtfully.

"No problem. My double-E lab instructor is a ham and he told me to place a parasitic choke in the plate lead. It's a new idea and it really works."

I examined the tiny choke hanging

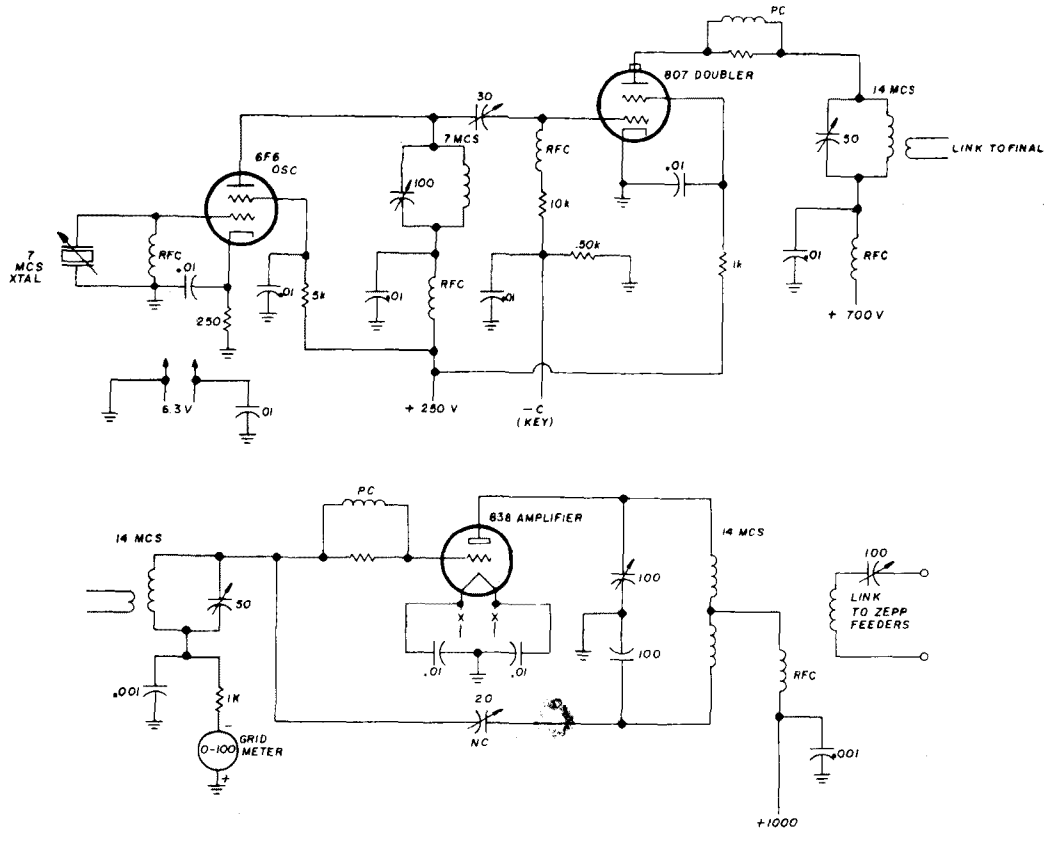


fig. 1. The 1941-model 20-meter DX transmitter. This transmitter delivers over 100 watts CW crystal controlled, on 20 meters. Representative component values are marked on the schematic. Pendergast built his transmitter in two sections. The 6F6 oscillator and 807 doubler were built on a small aluminum chassis. A variable crystal was used for quick frequency change. This was accomplished by a special crystal holder that had a variable air gap between the crystal blank and one holder plate. Adjusting the top plate changed crystal frequency. The 807 was keyed in the bias circuit. Cutoff bias was applied to the 807 and was removed when the key was closed. Pendergast soon found that a more complex keying system that reduced screen voltage under key-up conditions was required — otherwise a small back wave was heard in the keying intervals between characters.

The exciter was link coupled to the final amplifier stage, which was built on a separate aluminum chassis. Coaxial cable was generally unavailable in the 1940s, so Pendergast used twisted lamp cord for his link line. The 838 zero-bias triode was a forerunner of today's modern "grounded grid" tubes, such as the 3-500Z and the 8877. In this circuit, it was grid driven and plate neutralized. The split-stator tank circuit was coupled to a simple series-tuned circuit in the open-wire feeders to the end-fed Zepp antenna mounted high atop Pendergast's roof.

Want to build an old-time DX transmitter? This circuit will work today for you!

from the plate cap of the 807.

"Maybe the reason the 807 has such a bad reputation is that it goes into a parasitic oscillation," I guessed.

Pendergast ignored my remark and hurried on. "I have link coupled the 807 to the final amplifier, which is an 838 tube, one of those new zero-bias triodes. A really great tube. No bias required at all. So I key the 807 and the 838 goes along for the ride."

"Look at it!" said Pendergast with pride. "The 838 has 100 watts of plate dissipation. I run it at 1000 volts and nearly 200 mils plate current. Just about 200 watts input. And with the link coupling to the 807 I get plenty of grid drive."

"How is it to neutralize?" I asked.

"No problem. I just apply excitation with plate voltage off and watch the grid meter as I increase neutralizing capacity. When I can turn the plate tank condenser all the way around without a kick in the grid current, it is completely neutralized."

"Very good," I admitted. "I see you are using a split-stator tank circuit."

"Yep," said Pendergast. "And now I think it's about time to fire up and work some DX before the band goes dead for the evening."

Pendergast turned on the receiver and soon I could hear the crystal note of the oscillator's harmonic on 20 meters. He closed the side contact on the bug and quickly tuned the 807 to resonance. The note in the receiver grew intolerably loud. Pendergast flicked the rf gain control and my ears returned to normal.

I noticed my friend tuned his transmitter like a pro. Now, he quickly neutralized the final and adjusted the variable link coupling. Then he reached down and threw another switch. With a growl the power supply came to life, the 866s casting a blue tint across the lower portion of the panel. Pendergast retuned a bit, fussed with the antenna coupling and then said, proudly, "We're on the air. How about a little DX now?"

"Suits me fine," I replied. "What do you hear?"

Pendergast gestured to a second pair of headphones. "Let's tune the band," he said.

I donned the extra phones and listened. It had been almost a year since I had been on the air, and I was sure my CW was rusty. Pendergast tuned through a bunch of W9s and W6s as he approached the edge of the band.

"Listen!" Pendergast whispered to me. I closed my eyes to concentrate better.

"CQ . . . CQ . . . CQ . . ." Who was it? I opened my eyes and looked at my friend. "Certainly sounds DX-y," I said. "Listen to that fade on him."

The station faded into the noise and then started to come up again. It was a chirpy note, with a bit of an echo on it. Finally after an interminable wait, it signed:

"CQ de KF6ROV . . . KF6ROV . . . KF6ROV"

Pendergast grabbed a late copy of *QST* and rapidly flipped the pages until he came to the DX column.

"KF6 . . . KF6," he muttered to himself. "Who is *that*? Almost instantly he answered his own question.

"KF6 . . . that's *Baker Island*! Baker Island in the *Pacific*!"

"What a long CQ," I muttered. "By the time he signs, every ham in the world will be here."

"CQ de KF6ROV . . . KF6ROV . . . KF6ROV . . . K"

"Go get him, buddy-boy," I yelled.

Pendergast fired up the rig and reached for his key.

Out of the corner of my ear I heard a commotion downstairs. Miriam was calling something to us. There were excited voices talking back and forth. Hurried voices on the radio.

I looked at Pendergast. He was calling the KF6 now with his left hand and writing in the log with his right. Now, he was standing by. The earphones came to life.

We listened to the background noise for a second. Pendergast frowned as he heard his sister calling loudly to him as she ran up the stairs. Suddenly, there was the KF6. Calling Pendergast.

My friend let out a whoop and started to write in the log as Miriam burst into the room. Her face was white and she shook Pendergast by the shoulder as he wrote. I glanced in the log. Pendergast had just written: *December 7, 1941.*

The Japanese attack came just about sunrise, Hawaiian time, or about 1 o'clock EST. One of the first radio announcements was made by breaking into the New York Philharmonic Orchestra broadcast to announce the news flash.

Amateur Radio operation continued for a day or so. Many ham contacts were made with Hawaii, and confused reports of the raid filtered back via Amateur Radio and were picked up in the newspapers. On Monday, the FCC met in a special session and issued the following:

Order No. 87

At a session of the Federal Communications Commission held at its offices in Washington, D.C., on the 8th day of December, 1941;

Whereas a state of war exists between the United States and the Imperial Japanese Government, and the withdrawal from private use of all Amateur frequencies is required for the purpose of the National Defense;

IT IS ORDERED, that except as may hereafter be specifically authorized by the Commission, no person shall engage in any Amateur Radio operation in the Continental United States, its territories and possessions, and that all frequencies heretofore allocated to Amateur Radio stations under Part 12 of the Rules and regulations, BE, AND THEY ARE HEREBY, WITHDRAWN from use by any person except as may hereafter be authorized by the Commission.

By order of the Commission:
T.J. Slowie, Secretary

ham radio

how important is low SWR?

This controversy is put to rest once and for all

What, exactly, is the meaning of SWR? What significance does SWR have in Amateur Radio applications? Is a low SWR important?

This subject has always been a popular topic for discussion, and one ham may tell you something completely different from another. This article is written to tell you the facts about SWR. Then, you should be able to determine whether or not you should try to improve the SWR of your antenna system, or perhaps change to a better feed line. (Chances are quite good that you won't have to do anything at all to your present system!)

definition of SWR

When asked exactly what SWR is, many people will answer with something like, "Well, SWR is what you get a reading of when you hook up an SWR meter to your feed line." Then, although they have just admitted they don't know what SWR is, they'll probably add, "If it's more than 1.5:1, it's bad."

SWR is the relationship, or ratio, between the maximum and minimum currents and voltages along a transmission line; hence its name: standing-wave ratio. Ideally, the current and voltage are constant all along a transmission line. This ideal condition occurs when, and only when, the load (antenna) and the line have *equal impedances*. However, this ideal situation is seldom the case in this imperfect world of ours. More often than not, the load and line have impedances that are different — sometimes by quite a lot.

When the load and the line have different impedances, the current and voltage distribution along the line is not uniform. In some places the voltage will be high, and in other places it will be low; the same is true of the current. The VSWR (voltage standing-wave ratio) is the ratio of the highest voltage on the line to the lowest voltage on the line. When talking about SWR, it is generally understood that we are talking about VSWR, although the current standing-wave ratio is theoretically the same.

The SWR is also the relationship between the antenna, or load, impedance, Z_L, and the characteristic impedance of the line, Z_O. Mathematically it gets rather complicated, but if the load is resistive, SWR is the ratio Z_L/Z_O or Z_O/Z_L (whichever is greater than 1).

Often, you'll see SWR given as a ratio, such as 3:1. However, since 3:1 simply means 3/1, mathematically we might just as well do away with the "1" and say that the SWR is 3. (Any number divided by 1 is just the number, right?)

reflected power

Nowhere is the SWR misconception more widespread than with respect to "reflected power."[1] To understand what this really is, we must first know what power is. Power is defined as the rate at which energy is expended. Direction has nothing to do with power. Power is just dissipated someplace or places. In an antenna system, most of the power is dissipat-

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ed, one hopes, as radiation. Some power is dissipated as heat in the transmitter final-amplifier tank coil, some is dissipated in the feed line, and some is dissipated in objects surrounding the antenna.

Reflected power is, literally, what a directional wattmeter reads when put in the reflected power mode! Reflected power is *not* a force (expended energy) moving toward your rig from your antenna.

Even though reflected power is somewhat fictitious, being caused as a wattmeter reading only because of certain phase relationships and ratios between feed-line currents and voltages,[1] it is very useful in certain antenna calculations. That is, *if* it is properly interpreted.

forward power

If reflected power is a fictitious invention because power has no direction, the same is true of "forward power." The reading on a directional wattmeter in the forward-power mode is the sum of the actual transmitter output power and the "reflected power."

If you have ever used a directional wattmeter and observed that your transmitter was putting out 170 watts for a dc plate input of 200 watts, did you conclude that your rig was 85 percent efficient? If you did, you were probably wrong. (You know, of course, that 85-percent efficiency is virtually unheard of, even with class-C amplifiers.) Most likely, your SWR was high, causing an inflated "forward-power" reading. The actual output of the transmitter is the difference between the "forward power" and the "reflected power." (Think about it!)*

The relationship between the forward and reflected readings on a directional wattmeter is a function of the SWR. **Fig. 1** illustrates this function.

problems a high SWR may cause

A high SWR can, and sometimes does, cause certain problems. These problems include damage to the feed line, damage to transmitter components, reduced transmitter power output, and increased harmonic output. Let's discuss these one at a time.

The transmission line. Coaxial feed line in particular, and also certain other types such as TV ribbon line, can withstand only so much current and voltage. If the current becomes too high, the conductors will get so hot that they melt the dielectric material. If the voltage gets too high, arcing may occur between the conductors, again damaging the dielectric. This kind of problem rarely happens with power input levels of under 200 watts; but if you plan on using a kilowatt, you had better consider this possibility. For

*The power from the transmitter into the line is the sum of a) the power lost in and from the line and in any additional matching or other devices inserted into the line and b) the power delivered to the antenna (from reference 1).

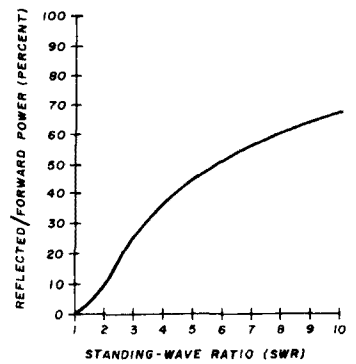


fig. 1. Relationship between SWR and the percentage of "forward power" that is "reflected."

a given power level, the higher the SWR, the higher the observed current and voltage will be. If you're using RG-58/U or TV-type twin lead, *don't* use a power input over 200 watts. If you're using RG-8U with a kilowatt, beware if the SWR is more than 5.

Depending on the exact length of the transmission line, you might have a current or voltage maximum at your transmitter. Excessive current can cause the transmitter tank coil to overheat and become damaged. Excessive voltage can cause arcing in the output loading capacitor. Usually this problem occurs only with transmitters that have wide-range pi networks with components that aren't sufficiently rugged. It's also quite rare for SWR values of less than about 4; but it can still happen.

Components. Solid-state transmitters are often designed to work into a 50-ohm nonreactive load and have no matching circuits to compensate for other loads. With some of these rigs, there is an "SWR pro-

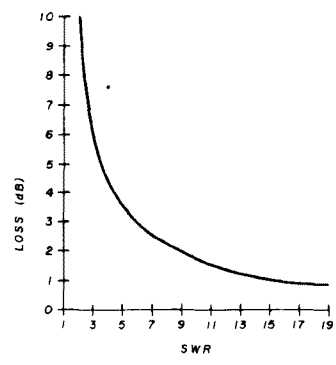


fig. 2. Determining the matched-line loss for old transmission line. Short circuit the far end of the line and measure the SWR at the input. The graph shows the relationship between SWR and matched-line loss.

table 1. Loss per foot, under perfectly matched conditions (SWR = 1), of various types of transmission lines commonly used by Amateurs. Accuracy is to two significant digits. (*1 foot = 3.05 meters.*)

cable type	characteristic impedance (ohms)	loss per foot, (dB) frequency (MHz) 3.5	7	14	21	28
RG-58/U*	52	0.0070	0.0100	0.0150	0.0190	0.0230
RG-59/U*	75	0.0065	0.0090	0.0130	0.0160	0.0180
RG-62/U*	93	0.0050	0.0072	0.0100	0.0130	0.0150
RG-11/U*	75	0.0038	0.0055	0.0080	0.0100	0.0120
RG-8/U*	52	0.0031	0.0045	0.0065	0.0081	0.0095
TV ribbon lead	300	0.0020	0.0030	0.0042	0.0054	0.0061

*Values are nominal since there are no set standards for commercial coax.

tection" circuit built in, but with many solid-state final amplifiers, damage can occur with an antenna system that presents a high SWR. If you have a solid-state rig, check your instruction manual to see if the final is "SWR protected." If it is not, check to see how *high the SWR* can be without risking damage to the output transistor(s), and be sure the SWR *is not above this limit*!

Output. Most commercially manufactured rigs will function all right if the SWR is less than 2 or 3. Some, with no output loading network, may tolerate an SWR of only 1.5 before power output is degraded. Certain of the older-vintage radios will compensate for SWR levels up to 5 or even 10. The radio's instruction manual should tell you how high the SWR can get before power output is degraded. If the SWR is beyond this limit, the final amplifier will not operate at full efficiency because the impedance mismatch will be too severe. If your loading control must be set to one extreme or the other to get a semblance of proper final-amplifier tuning, the SWR is too high for the circuit.

Harmonics. If the loading capacitor must be set all the way to maximum and you still can't get the transmitter to tune to the required power input level, you're being forced to under-load the transmitter. This can cause increased harmonic output, because under-loading causes nonlinearity in the final amplifier.

Of these problems, three can be eliminated by using a transmatch at the transmitter output. A "perfect" impedance match will then be presented to the transmitter. The transmatch will normalize the currents and voltages in the transmitter tank circuit, thus maximizing energy transfer and preventing under loading. The possibility of feed-line damage still remains, however, (as explained previously) unless the transmatch is placed at the point where the line feeds the antenna. This is generally not very convenient.

problems a high SWR doesn't cause

A high SWR, by itself, will *not* make a feed line radiate, and will *not* make an antenna less efficient. A perfectly matched feed line may radiate, and may be terminated by a grossly inefficient antenna (for example, a dummy load!). These problems are *not* related to SWR. If the transmitter can be properly loaded, a high SWR will *not* cause radio-frequency interference (RFI) that would not otherwise occur.

Surprisingly enough, at high frequency, a high SWR will generally not cause very much loss of signal. With several hundred feet of RG-58/U at 28 MHz and an SWR of, say 20, there will admittedly be a lot of loss because of the SWR. But this is an extreme case. In ordinary applications, the SWR can be surprisingly high before serious signal loss occurs.*

We will now investigate this phenomenon quantitatively. With the following information, you will be able to:

1. Determine how much signal loss your SWR is causing.

2. Find out whether or not it is significant.

3. Tell whether changing the feed line type, such as from RG-58/U to RG-8/U, is worth it, and perhaps

4. Save a lot of time, energy, money, and grief.

matched-line loss

Table 1 shows the loss in dB per foot for the most common types of transmission lines used by Amateurs. The numbers in **table 1** are based on perfectly matched systems; thus the antenna must have a pure resistance of 52 ohms for RG-8/U and RG-58/U, 75 ohms for RG-59/U, and 300 ohms for TV ribbon, for these data to be correct. However, the

*Consider the end-fed Zepp antenna of 50 years ago. These antennas were efficient even with an SWR of 10 or more. **Editor**

table 2. Actual SWR as a function of matched-line loss (vertical) and the apparent SWR (horizontal). SWR values greater than 10 are indicated by x. SWR values above 6 are accurate to about ±0.5.

line loss matched (dB) \ apparent SWR (at transmitter)	1.0	1.2	1.4	1.6	1.8	2.0	2.5	3.0	4.0	5.0	6.0	7.0
0	1.0	1.2	1.4	1.6	1.8	2.0	2.5	3.0	4.0	5.0	6.0	7.0
0.2	1.0	1.2	1.4	1.6	1.9	2.1	2.6	3.1	4.2	5.5	6.8	8.0
0.4	1.0	1.2	1.4	1.7	1.9	2.1	2.7	3.4	4.7	6.3	8.0	9.5
0.6	1.0	1.2	1.5	1.7	2.0	2.2	2.9	3.7	5.2	7.6	10.0	x
0.8	1.0	1.2	1.5	1.7	2.0	2.3	3.1	4.0	6.0	9.0	x	x
1.0	1.0	1.2	1.5	1.8	2.1	2.4	3.3	4.3	7.0	x	x	x
1.2	1.0	1.3	1.5	1.9	2.2	2.6	3.6	4.8	8.3	x	x	x
1.4	1.0	1.3	1.6	1.9	2.3	2.8	4.0	5.5	9.9	x	x	x
1.7	1.0	1.3	1.6	2.0	2.5	3.0	4.3	6.5	x	x	x	x
2.0	1.0	1.3	1.7	2.1	2.8	3.3	5.3	8.4	x	x	x	x
2.5	1.0	1.4	1.8	2.4	3.2	4.0	8.0	x	x	x	x	x
3.0	1.0	1.4	1.9	2.7	3.7	4.9	9.8	x	x	x	x	x
3.5	1.0	1.4	2.1	3.1	4.6	6.9	x	x	x	x	x	x
4.0	1.0	1.5	2.3	3.7	6.0	10.0	x	x	x	x	x	x
4.5	1.0	1.6	2.6	4.7	7.9	x	x	x	x	x	x	x
5.0	1.0	1.8	3.0	6.0	x	x	x	x	x	x	x	x
5.5	1.0	2.0	3.4	8.5	x	x	x	x	x	x	x	x

information in **table 1** is essential for determining the SWR loss in your system — so get it down.

For example, suppose you are using 60 feet of RG-58/U at 7 MHz. The loss is 0.01 dB per foot, so the total loss under perfectly matched conditions is 0.01 x 60 or 0.60 dB.

If your SWR happens to be 1, then you already know what the feed line loss is. You thus have no use for **tables 2** and **3**. But if the SWR is not 1, there will be additional loss in the line. This additional loss is sometimes called "SWR loss."

Incidentally, the data in **table 1** are for brand-new cable. Coaxial cable gets lossier with age. Some types are better in this regard than others. Generally the foam dielectric type deteriorates faster than the solid dielectric type. There is a way to check old transmission line to find out what the loss really is. Short-circuit the far end of the line and place an SWR

table 3. Additional loss caused by standing waves. Find the line loss when perfectly matched in the vertical column; read across for the actual SWR. Find the figures that are closest *to yours if yours are not* exactly represented. Conditions above and to the left of the heavy line indicate an SWR loss of less than 1 dB.

line loss matched (dB) \ actual SWR (at antenna)	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
0	0	0	0	0	0	0	0	0	0	0	0	.0
0.2	0	0	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.6	0.7
0.4	0	0	0.1	0.2	0.2	0.4	0.5	0.7	0.8	1.0	1.1	1.3
0.6	0	0	0.1	0.2	0.3	0.5	0.7	0.9	1.1	1.3	1.5	1.7
0.8	0	0	0.2	0.3	0.4	0.7	0.9	1.2	1.5	1.7	1.9	2.1
1.0	0	0	0.2	0.3	0.5	0.8	1.2	1.4	1.7	1.9	2.2	2.5
1.2	0	0	0.2	0.4	0.6	1.0	1.3	1.7	1.9	2.2	2.5	2.8
1.4	0	0	0.3	0.4	0.6	1.1	1.5	1.8	2.1	2.4	2.7	3.0
1.7	0	0	0.3	0.5	0.7	1.3	1.7	2.0	2.3	2.6	3.0	3.3
2.0	0	0.1	0.3	0.5	0.8	1.3	1.8	2.1	2.5	2.8	3.2	3.6
2.5	0	0.1	0.3	0.6	0.9	1.5	1.9	2.3	2.8	3.1	3.5	3.7
3.0	0	0.1	0.4	0.6	1.0	1.5	2.0	2.5	2.9	3.2	3.7	4.0
3.5	0	0.1	0.4	0.7	1.1	1.6	2.1	2.6	3.1	3.4	3.8	4.1
4.0	0	0.1	0.4	0.7	1.1	1.7	2.2	2.7	3.2	3.5	3.9	4.2
4.5	0	0.1	0.4	0.7	1.1	1.7	2.3	2.8	3.2	3.6	4.0	4.3
5.0	0	0.1	0.4	0.8	1.2	1.8	2.3	2.9	3.3	3.7	4.1	4.4
5.5	0	0.1	0.5	0.8	1.2	1.8	2.4	2.9	3.3	3.8	4.2	4.5

meter at the transmitter output. Measure the SWR with a small amount of power. Fig. 2 shows the relationship between SWR and perfectly matched line loss for this method.

The concept of reflected power is useful for obtaining the data for **fig. 2**. With a short circuit at the antenna end of the line, we may assume that 100 percent of the power is reflected, since a short circuit cannot dissipate power. Then, based on the SWR versus reflected power function, we can figure out what proportion of the power "came back" to the SWR meter to be registered as reflected power. The remainder was dissipated as heat in the line.

actual and apparent SWR

Most hams measure their SWR in the station at the transmitter output. However, measuring it at this point does not give an accurate reading. The *actual* SWR, the quality of the match between the antenna and the feed line, must be measured at the antenna if an SWR indicator is to give accurate results. The reading you get in the station is the *apparent* SWR, and is always less than the actual SWR. Sometimes the difference is considerable.

To accurately determine the SWR loss in your feed line, you need to know the actual SWR. This can be found out, of course, by climbing your tower or renting a "cherry picker" and physically placing an SWR indicator at the proper point. But there is an easier way.

If you know the line loss under perfectly matched conditions (from **table 1** or **fig. 2**), **table 2** will give you the actual SWR as a function of the apparent SWR.

Once you know the actual SWR as well as the line loss under perfectly matched conditions, you are ready to find the SWR *loss* — the extra feed line loss caused by standing waves on the line.

is it significant?

Use **table 3** to determine the SWR loss in your feed line. Does the result surprise you? How do you know whether or not it is significant?

In general, if the SWR loss is less than 1 dB, you are wasting your time by striving for a perfect match. A change in signal strength of 1 dB is recognized as the smallest detectable change; therefore, in practice, anything less is nothing. A gain of less than 1 dB will not be detected by the other station under any conditions. In **table 3**, the heavy black line differentiates between significant SWR losses (lower right) and those that are not significant (upper left).

Just because you have an SWR loss of less than 1 dB does not mean that you have a good antenna. It simply means there is no point in trying to get a better match with the existing feed line. A 2000-foot (*1 foot = 0.305 meter*) run of RG-58/U at 21 MHz will be very lossy even if the SWR is 1. A 3-foot loaded vertical without radials at 3.5 MHz will have a lot of inductor and ground losses, even if it displays an SWR of 1. A small SWR loss does not make up for a poor antenna or feed line system.

The data here can be used to determine whether or not it is a good idea to change your feed line. Suppose, for example, that you are using 300 feet of RG-59/U with an antenna having a pure resistive impedance of 75 ohms, so the SWR is 1. At 21 MHz there will be 4.8-dB loss in the line (**table 1**), although none of it is attributable to the SWR. Would it be worthwhile to change to RG-8/U, which has a 52-ohm characteristic impedance?

Using **table 1**, note that 300 feet of RG-8/U has 2.4 dB loss at 21 MHz. The SWR using this cable will be 1.5 (75/52), so there will be some SWR loss. How much? Table 3 tells us it will be only 0.1 dB, giving an overall feed-line loss of 2.5 dB. This is an improvement of 2.3 dB over the perfectly matched run of RG-59/U! A change of 2.3 dB is fairly significant. If money is no object, this change would be worthwhile.

The above is a rather unusual example, but in addition to showing you how to use these data, it illustrates another point as well: feed line loss is not a simple direct function of SWR.

conclusion

For all practical purposes, an actual SWR of 2.5 or better is just as good as a perfect match, as far as loss is concerned. This is apparent from examining **table 3**. So next time you try out a new antenna, don't throw your hands up in dismay and declare that it is no good just because your SWR meter reads 1.7!

The data presented here are primarily intended for the DXer or contester, since optimum antenna performance is especially important for them. Actually, a good antenna is important in any ham station. Of course we should try to optimize antenna systems. But there is a point of diminishing returns. The fear of an SWR that's not perfect or near perfect can take the fun out of hamming — not because there is anything actually wrong, but because you *think* there is. Now you know the real story. If your SWR loss is less than 1 dB and you're using the best grade of feed line you can, you have no more excuse not to get on the air and start operating!

reference

1. For a detailed discussion of reflected power, see: Hubert Woods, "Power in Reflected Waves," *ham radio*, October, 1971, page 49. Also see "Comments," *ham radio*, December, 1972, page 76.

ham radio

Amateur Radio equipment survey:
synthesized 2-meter hand-helds

High-frequency rigs have received all of the attention in the *ham radio* equipment surveys thus far, and so the editors have decided that it's about time to let VHFers have a voice. This month, *ham radio* is surveying its readers' opinions of five of the most popular 2-meter hand-helds. The five are the Santec HT-1200, Tempo S-1 and S-5, ICOM IC-2A and 2AT, Yaesu FT-407, and Kenwood TR-2400.

All of these radios are frequency-synthesized, and all of them have now been around long enough for Amateurs to have had a chance to put them through their paces and come up with a fair appraisal. Two-meter portables have become enormously popular in recent years, thanks mostly to the technological innovations that have made possible PLL synthesizers, multi-channel memories, and — just as important — reasonable prices. Attend any ham convention and you'll see just how well-liked these hand-helds really are: they're everywhere.

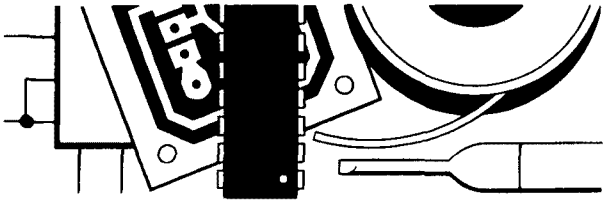
The information that we're requesting is designed to help us get the clearest picture possible of what the owners of these radios think about them — what kind of problems they've had, what they think the best features are and what the worst. If you own or have owned one of these radios, please take the time to fill out the questionnaire. Only that way will other Amateurs be able to take advantage of your experiences.

The results of this survey will be published as soon as all of the results have been received and tabulated. It is not mandatory that you give your name and call, although we like to know who has replied. By checking the box marked *Yes* underneath your signature, you will be giving *ham radio* permission to quote from your comments and use your callsign. If you choose to check *No*, your wishes will be respected and your callsign will not be used. Those who do not wish to remove pages from their magazine are urged to photocopy the questionnaire, or send a stamped, self-addressed envelope to *ham radio*, Greenville, New Hampshire 03048; we will send you a copy.

Please mail in your completed form, one for each radio you want to report on, no later than September 30. Questionnaires received after that date may not be used. The readers of *ham radio* have always, in past surveys, been eager to let other hams in on their experiences with Amateur equipment — to let a fellow ham in on a good deal or warn him away from a bad one. Here is another chance to lend a hand to a fellow Amateur.

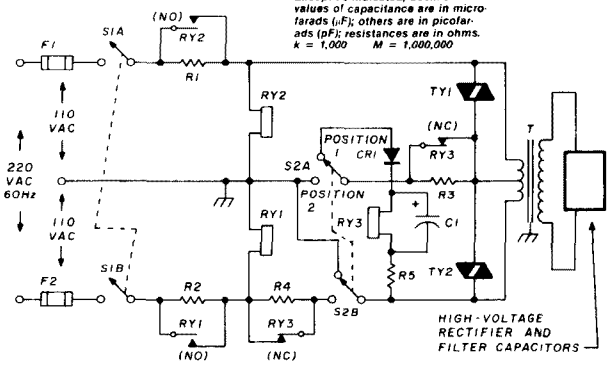
ham radio

the weekender



dual voltage surge-protection circuit for high-voltage power supplies

The circuit described here features dual output voltages with current surge protection. I developed the circuit so I could obtain, from one dc source, 2000 volts dc for my 3-500Z and 4000 volts dc for a 4-1000A linear amplifier conveniently and at minimum cost.



C1 approximately 1000 μF. Adjust value of C1 to set relay dropout time at approximately 2.5 seconds (see text)
CR1 2.5 amp, 1000 V (NEP 170 or equivalent)
F1, F2 fuse according to your supply requirements
R1 25 ohms 40 watts
R2 25 ohms 40 watts
R3 25 ohms 40 watts
R4 25 ohms 40 watts
RY1, RY2 120 V ac relay, SPST, with 25-amp contacts
RY3 dc relay, DPST, with 25-amp contacts
S1 DPST, 15 A contacts; 30 A for 2 kW linear amplifier supply
S2 DPDT, 15 A contacts; 30 A for 2 kW linear amplifier supply
T high-voltage transformer with 220 Vac c.t. primary, or two 110 Vac primary-winding high-voltage transformers in series. Secondary voltage for your high-voltage requirements
TY1, TY2 6RS20SP585 thyrector

parallel combinations can be used. Example: two 50-ohm 20 watts

fig. 1. Schematic of the high-voltage primary circuit. Surge protection for power-supply components is provided during the instant of turn-on.

circuit description

Because of the very large secondary filter capacitor (or capacitors) in a linear amplifier power supply, it's necessary to apply voltage *slowly* to this capacitor to prevent tremendous current surges, which could destroy the power supply components. See **fig. 1**.

When the high-voltage power supply is first turned on, the filter capacitor presents a short circuit. This low impedance is reflected back through the high-voltage power transformer, T, and short circuits the coils of relays RY1 and RY2. The contacts of these relays are normally open, and resistors R1 and R2 decrease the 110 volts. As the filter capacitor charges, the voltage drop across resistors R1 and R2 decreases. When the voltage across the relay coils reaches the pickup voltage of the relays, the contacts of these relays close, shorting out resistors R1 and R2, which applies full voltage to the primary winding of the power-supply transformer.

When the output voltage switch, S2, is set for low voltage (position 1), the same process applies, but only relay RY2 operates. When switching the supply from low to high voltage, the voltage applied to the filter capacitor must again be increased slowly. This action is accomplished by components CR1, C1, R5, and relay RY3. When the power supply is switched from low to high voltage, capacitor C1 retains a voltage across the coil of relay RY3 for a time determined by C1 and the internal dc resistance of the relay coil. (Time constant = RC.)

Since the contacts of RY3 are normally closed, resistors R3 and R4 are short circuited when the voltage across C1 decreases below the dropout voltage of the relay. This action brings the voltage of the filter capacitor to the high output-voltage value. An additional feature of the circuit is that, if a voltage breakdown short circuit should occur in the linear amplifier during operation, relay RY2 and/or RY1 will drop out and provide limited current surge protection.

This circuit has given excellent service. Components for the circuit are not critical as long as each has an adequate current and voltage rating.

By Edwin Hartz, K8VIR, 108 Hartz Drive, Holly, Michigan 48442

bibliography

Marcellino, F.T., W3BYM, "Inrush Current Protection for the SB-220 Linear," (*Weekender*), *ham radio*, December, 1980, page 66.

ham radio

Questions and Answers

Entries must be by letter or post card *only. No telephone requests will be accepted. All entries will be acknowledged when received. Those judged to be most informative to the most Amateurs will be published. Questions must relate to Amateur Radio.*

Readers are invited to send a card naming the question they feel is most useful that appears in each issue. Each month's winner will receive a prize. In addition we will have a drawing of all the voters each month, and that winner will receive a prize. We will also give a prize for the most popular question of the year. In the case of two or more questions on the same subject, the one arriving the earliest will be used.

radio propagation

In the "DX Forecaster" column, mention is made of the terms solar-flux values and geomagnetic-field disturbances. I recognize these as the same as those I hear on WWV at 18 minutes after the hour. Could you explain these and other terms (A index, K index) and how they affect radio-frequency propagation? — Kathleen N. Freeman, KL7IFF.

These terms were discussed by Jim Gray, W2EUQ (now W1XU), in the September, 1977, issue of *Ham Radio HORIZONS*. We have had other inquiries on this subject, so it seems worthwhile to explain these terms again.

solar flux and geomagnetic A indexes

For best propagation of radio signals on the high-frequency bands, a relatively high solar flux and low geomagnetic A index are desirable. The solar flux is measured at 2800 MHz and consists of radio noise whose magnitude has proven to be analogous to the magnitude of the energies that excite the **E** and F layers of the ionosphere. Solar-flux magnitudes range from about 65 to 150 and can be roughly equated to smoothed sunspot numbers and Maximum Usable Frequencies (MUF).

geomagnetic activity A index

This number tells how well the ionosphere has performed with respect to the reflection and absorption of radio signals, or both, particularly in the polar regions. An **A** index of 0-7 means excellent reflection of signals from the ionosphere, whereas an **A** index of 50 or more would indicate that a major magnetic storm is occurring, with severely disturbed, if not disrupted, radio-propagation conditions. Intermediate values indicate the relative condition of the earth's electromagnetic field.

solar K index

Also broadcast from WWV at 18 minutes past the hour, this data is updated every six hours. The **K** index ranges from 0 to 9 and corresponds to the **A** index of from 0 to 50 respectively. **Fig. 1** shows how the various indexes relate to expected radio-propagation conditions.

tube or solid-state finals?

Would you please outline the primary advantages and disadvantages of tubes versus solid-state final amplifiers? — Lewis I. Hegyi, N2BPO

First, let's talk about power. Tubes are being used in most of today's high-powered linears. Solid-state technology, however, is beginning to produce devices that are capable of furnishing large amounts (several hundred watts) of rf energy. At least three manufacturers of Amateur equipment are now producing solid-state linear amplifiers that are capable of running at or near the Amateur legal limit. But it's probable that tubes will still be around for a while.

One of the advantages of tubes is that they are much more forgiving of mismatched loads. It's pretty hard to damage a tube amplifier when trying to make it work into a load presenting

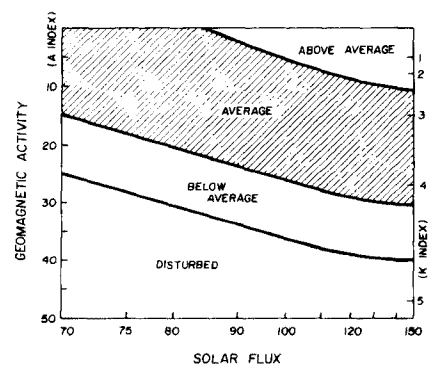


fig. 1. Relationship between geomagnetic and solar flux indexes and their combined effect on ionospheric propagation of radio signals.

a high standing-wave ratio. A transistor amplifier, on the other hand, will almost certainly be damaged under these conditions unless it has built-in overload protection. Also, tubes are easier to replace than transistors, especially in modern high-density solid-state circuits.

An advantage of solid-state finals is that transistors are smaller than tubes, which allows a lot of radio to be packaged into a small volume.

There's a difference in power-supply requirements for the two types of amplifiers. Solid-state amplifiers require supplies that produce large amounts of current at low voltage, while the opposite is true of tube rigs. An advantage of the solid-state amplifier in this case, of course, is that the danger of high voltages is eliminated.

selecting equipment

Having had no previous experience in Amateur Radio, I find myself drawing blanks when reading ads for ham gear. What are all those switches, dials, knobs, bells and whistles for anyway? How do I go about selecting ham gear when I have no idea what everything is or does? What are my options? — Dr. Crosby Pulliam.

Selecting ham gear pretty much depends on your sphere of interest, such as high-frequency communications, VHF/UHF, microwaves, or whatever. If you decide to work the high-frequency bands *and want to* select a commercially manufactured receiver, transmitter, or transceiver, you can write to the manufacturer of the radio of your choice and order an instruction manual. The manual will provide details of the radio's features, both from a theoretical and operating standpoint.

Or you can enlist the aid of a reputable ham-equipment dealer. Many have radios set up and operating, complete with antennas. Visit a dealer and ask for help in selecting a radio, then try it out (assuming you're licensed, of course). You'll find salespeople helpful and ready to answer your questions.

An alternative is to ask a ham friend to demonstrate his equipment. Some of the features you'll like, others perhaps not, depending on how you plan to operate. The controls and switches on today's equipment look mighty impressive to a beginner, but each one considered separately is not all that mysterious.

A good idea is to ask still another ham friend to demonstrate *his* equipment and explain its features. Keep in mind that your friends are partial to their equipment. Features that may appeal to one person may not appeal to others. Take a notebook and jot down your likes and dislikes.

For example, suppose you're interested in CW DX operating and want a receiver that will fit these requirements. You'll want a receiver with excellent mechanical and electrical stability as well as good sensitivity and selectivity.

Choose a receiver that has passband tuning, a notch control, and a sharp CW filter. With these three features you can virtually eliminate strong interfering signals and hear the desired DX signal, which would otherwise be inaudible. Passband tuning allows you to move the interfering signal around within the receiver's i-f passband. Then, by varying the notch control, you can null out the interfering signal or at least reduce its amplitude until you can hear the desired signal. Now, with the CW filter switched into the circuit, you'll have just about the best selectivity anyone could want.

A recommended book to help the beginner become acquainted with Amateur equipment is the ARRL's *Understanding Amateur Radio,* available from Ham Radio's Bookstore for $5.00 plus $1.00 postage and handling.

off-the-air tune up

I dislike the possible annoyance I might cause to other stations by putting a signal on the air when matching my antenna to my radio. Is there a way to match my set to my antenna without causing interference? — Donald G. Ramras, M.D., KD6GR.

It would be great if others had your unselfish attitude toward this problem. Some hams are conscientious and take steps to tune their antennas without radiating an interfering signal. They use accepted methods for tune up and keep charts to indicate control settings for their equipment for different frequencies and bands. Others use the brute-force method and tune their rigs while on the air — never mind the interference!

dummy load

First of all, you'll want to tune your transmitter to resonance without an antenna. A dummy load, representing the impedance into which your transmitter works, is the best device. A dummy load can be one of the many commercially available versions, consisting of a 50-ohm nonreactive resistor immersed in a cooling liquid, such as transformer oil. Most Amateur transmitters want to see a 50-ohm nonreactive load. After you've tuned up your transmitter into a dummy load of this impedance, you're ready to match the transmitter to your antenna.

Amateur antennas have an input impedance varying from 50 ohms (dipole or Yagi beam) to several-hundred ohms (extended double Zepp, multiple-band dipole, long-wire). For antennas such as these, you'll need an impedance-matching device (sometimes referred to as a transmatch). This apparatus is designed to help you match your antenna impedance to that of your transmitter.

For complete off-the-air tune up you'll need, in addition to the dummy load and transmatch, a receiver with good frequency calibration, and an antenna noise bridge. The noise bridge will help you determine the resonant frequency of whatever antenna you are using.

the noise bridge

This instrument consists of two basic elements: a bridge circuit and a noise source, usually a diode. Connect the bridge to your receiver, and connect the receiver to your antenna. When the bridge is balanced, a null will occur in your receiver, indicating the resonant frequency of your antenna.

One arm of a typical bridge consists of a potentiometer and dial that indicates resistance. When you obtain a null, the potentiometer dial will indicate the resistance of the tuned circuit (antenna). The resonant frequency of the antenna will be indicated by your calibrated receiver.

Ideally, the null will occur only when the antenna input impedance is a pure resistance. Some noise bridges include a "reactance" control; others do not. If your noise bridge does contain a reactance control, this control should be adjusted, along with the other controls, to obtain a null. Noise bridges that do not contain a "reactance" control may or may not include a reactive component in their indication of antenna impedance.

When using the antenna noise bridge with your receiver, you'll probably have to adjust your antenna-matching network (transmatch) to obtain a sharp null in the receiver and a resistance of 50 ohms, as indicated by the antenna noise bridge. Once these adjustments have been made, you can be sure that your antenna system is resonant and ready to take power from your transmitter.

Before connecting your transmitter to the antenna, however, the transmitter *should have been tuned to resonance* with its output connected to a dummy load. When this condition has been met, you know the transmitter is working into a nonreactive 50-ohm load. You can then disconnect the dummy load from the transmitter and connect the transmitter to your antenna, which has been tuned to resonance, as described previously.

ham radio

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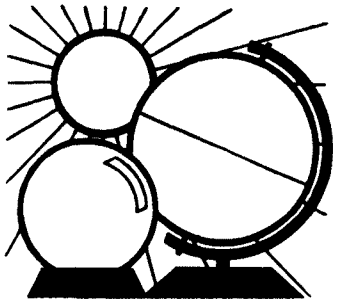
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DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

The higher frequency bands are expected to provide good DX openings during the first week of the month. Then DX conditions will probably wilt like a DXer in the August heat, while the nighttime DX will have the better openings. Of course, the QRN may take some of the joy out of that unless you're game for the early-morning, pre-dawn hours. The higher bands should again come into their own with good DX toward the end of the month. Disturbed propagation conditions may appear around the 8th and 25th for short, solar-flare-related periods of a one or two days' duration, then around the 17th for a coronal hole period of three to five days' duration.

The lunar perigee is on the 22nd and full moon on the 15th this month. The Perseids meteor shower occurs from the 10th to 14th, with its maximum the 11th and 12th at better than fifty meteors per hour.

August is a good month for short-skip openings by Sporadic-E (Es), but one of the last this Es season. The long hours of daylight will begin to fade noticeably by the end of the month.

forecasting

In the June DX Forecaster I gave some basic ideas on how propagation predictions are usually made. Here is some more shop talk about forecasting. Rather than trying to increase the accuracy of predictions by more closely defining variations of the ionosphere, better we shorten the length of the time in advance of when the prediction is needed — that is, until the day or hour before. We can of course try to keep track of the geophysical factors that could alter the prediction. This is like using low or high pressure areas, fronts, and winds in weather forecasting to say what the weather is going to be like. The geophysical factors found to be best for forecasting the ionosphere are the solar flux (in place of sunspot numbers) for predictions days in advance and the magnetic field variability within three hours (K figure) or daily (A figure) for predictions hours in advance.

As the solar radio flux goes up, expect the mid-latitude maximum usable frequency (MUF) to go up, after a two- to three-day delay. Or, as the geomagnetic field increases its variability (A or K becomes larger), the MUF will drop overnight. The amount of drop is a function of geomagnetic latitude, varying inversely from 30 degrees to the auroral zone (about 60 degrees). The MUF increases directly with geomagnetic latitude everywhere else. So you can forecast how the ionosphere propagation is going to behave from day to day or hour to hour by checking the daily solar flux value and geomagnetic A and K values from radio station WWV at 18 minutes after each hour.

Alternative to keeping track of the ionospheric propagation, you can plot signal strength for your favorite DX QSOs to a particular location. Plot each QSO signal strength at a point on a linear graph with abscissas of solar flux (70-200 units) and ordinates of the geomagnetic A value (0-50 units). As the number of QSOs plotted grows, a family of similar signal strengths builds so as to be usable for forecasting signal strengths from solar flux and A values. For more detail and examples of this method see articles in *CQ* magazine for September, 1974, by Cohen; March, 1975, by Jacobs and Cohen; August, 1979, by Cohen and Jacobs; and in *QST* magazine for September, 1977, by Sartoni. It works! The North Atlantic forecast on radio station WWV over the years was done essentially by this method on a six-hour forecast period using the past two measured geomagnetic K values.

band-by-band forecast

Ten and fifteen meters should provide excellent daytime openings. The hours of daylight should begin to be noticeably shorter particularly toward the end of the month. Watch for the best openings during periods of high solar flux. They should be north-south paths to Africa, South America, and the South Pacific. A sun-following sequence of Africa in the AM local time, South America in the early PM, and South Pacific in the late afternoon is usually seen from most QTHs in the U.S.A. Fifteen will be open a little before ten and will last a little longer in the evening.

Twenty meters will be open around the clock on most days and will be the long-skip/short-skip workhorse of the high-frequency DX bands. Signals will peak in the morning and afternoon hours, but will be readable to one area or another all the day and night.

Forty meters is going to start coming back strong, except for the high QRN levels during local thunderstorms.

Eighty and one-sixty meters will become active once again for DX during the nighttime hours, with strong openings into the south. High QRN levels will still be a problem generally, but they will be almost usable between local thunderstorms.

ham radio

AUGUST

GMT	POT	WESTERN USA												MDT	MID USA											CDT	EASTERN USA											EDT
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		N	NE	E	SE	S	SW	W	NW						N	NE	E	SE	S	SW	W	NW				N	NE	E	SE	S	SW	W	NW			
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1100	4:00	—	—	—	—	—	20	15	40*					5:00	—	20	—	—	—	20	20	—				6:00	—	—	—	—	—	20	20	—			7:00
1200	5:00	—	—	—	—	—	20	20	40*					6:00	—	20	—	—	—	20	20	—				7:00	—	20	—	—	—	20	20	—			8:00
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*Look at next **higher** band for possible openings.

two delta loops fed in phase

Another version of this popular antenna eliminates the suspension boom

Many months ago Ken Bale, W7VCB, sent me a copy of an antenna article describing a "ZF Special" antenna by ZF1MA in Grand Cayman, B.W.I. It used a pair of connected delta loops suspended from a 20-foot boom, as in **fig. 1**. Once in a while I would look at this idea and discard it, because 20-foot booms are pretty difficult to come by, not to mention to erect.

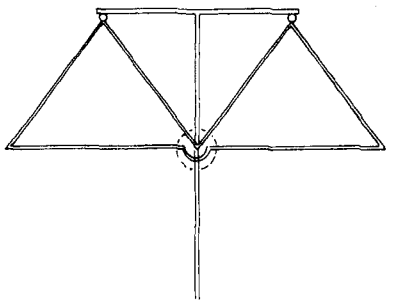


fig. 1. The "ZF Special uses pair of delta loops suspended from a 20-foot boom. Antenna is vertically polarized, since it is fed at one corner.

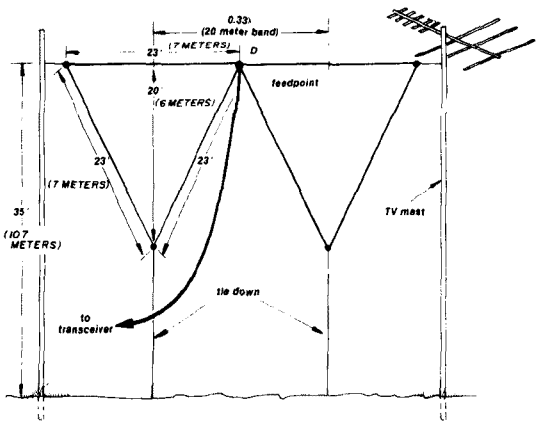


fig. 2. The improved phased delta-loop array is suspended by nylon line, thus eliminating the boom. Antenna is fed at the top, which keeps the high-current point as high as possible.

Then one day I said to myself, "Why a boom?" I turned the page upside down and mentally suspended the antenna from a nylon rope running from my 50-foot TV tower to a mast 48 feet away. It looked interesting. I'd often used both 20-meter and 15-meter loops suspended this way, but never two of them at a time.

I decided that what ZF1MA had was two full waves in phase, and that the array was vertically polarized, since they were fed at a corner.

improved phased delta-loop array

Fig. 2 shows the result of my efforts. I changed the feed point to the flat top to keep the high-current point at the top. Feed-point detail is shown in **fig. 3**.

So what do we have? A single delta loop has a gain of close to 2 dB referenced to a dipole. A pair of them at the close spacing shown will add another 2 dB. The pattern will be as in **fig. 4**.

If the antenna is oriented so that one lobe is toward Europe, the other lobe will be toward the South Pacific. Or you can orient the antenna so that Japan and the South Atlantic are covered.

My antenna is aimed at Antarctica in one direction and European USSR and the Persian Gulf in the other. It has provided excellent results with phone-patch traffic between my location and McMurdo Station, Antarctica. It has also performed well with many other DX stations on the 20-meter band.

If I had more space, I'd use the feed system in **fig. 5**, which provides *horizontal polarization*. (Incidentally, Bill Orr's *Antenna Handbook* shows that a delta loop fed in this manner yields a substantial, low-angle, vertically polarized signal.)

element-spacing considerations

Although the elements of my antenna are spaced as closely as possible without overlap (0.33 wavelength, or 23 feet, center-to-center, for the 20-meter band), wider spacing would increase gain, as shown below.

For two elements (20-meter band):

spacing wavelength	feet	(meters)	gain (dB)
0.33	23	(7)	2.0
0.40	27	(8)	2.8
0.50	34	(10)	4.0
0.65	44	(13)	4.8

The gain numbers shown are in *addition* to the 2-dB gain for a delta loop over a dipole.

By Jerrold A. Swank, W8HXR, 657 Willabar Drive, Washington Court House, Ohio 43160

For more than two elements, with half- and three-quarter wavelength spacing, here are the gain figures (from the ARRL *Antenna Book*):

number of parallel elements	half wave-length spacing gain (dB)	3/4 wave-length spacing gain (dB)
3	5	7.0
4	6	8.5
5	7	10.0
6	8	11.0

other arrangements

I can picture some lucky ham who lives on a farm and who could stretch out a series of six elements with half-wavelength spacing for 10-dB total gain; or with 3/4-wavelength spacing for 13-dB gain, suspended from trees or a row of telephone poles. Or how about two arrays at right angles to each other, with the intersection at a cross point of two fence rows, using no farmland space?

With an antenna gain of 13 dB, you'd have a power gain of 20, which would make a 2 kW PEP signal sound like 40 kW!

For two band operation, spacing for the 15-meter band at 3/4 wavelength would be the same as half-wavelength spacing for the 20-meter band. And you could suspend the 15-meter-band loops inside each 20-meter-band loop.

Each delta loop has a feed-point impedance of about 120 ohms, so a pair is about 60 ohms, which is what mine measure. For more loops, the impedance should be as follows, with each feed line being the same length:

Four loops, 30 ohms with an SWR of 1.7:1 and six loops with a 2.5:1 SWR. None of these will be difficult to match.

It would probably be well to use a 1:1 balun at each feedpoint.

concluding remarks

Stations from the South Atlantic, the Caribbean, and South America really pound in here during the day, with many pinning my meter at 60 dB over S9. At night, the Antarctic stations are often over S9 and are easy phone-patch quality both ways.

Oh, yes — if you want to make a unidirectional beam, you can stretch a director or reflector element, or both, about 8 feet from the center of the array. Use a single wire 31 feet, 2 inches for the director and 34 feet, 6 inches for the reflector. This arrangement will, of course, reduce the feed point impedance, making some sort of tuner or matching section necessary to reduce the SWR. This is especially important if you have one of the new solid-state rigs, which are intolerant of high SWR.

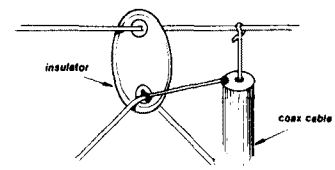


fig. 3. Feed-point detail of the phased delta-loop array.

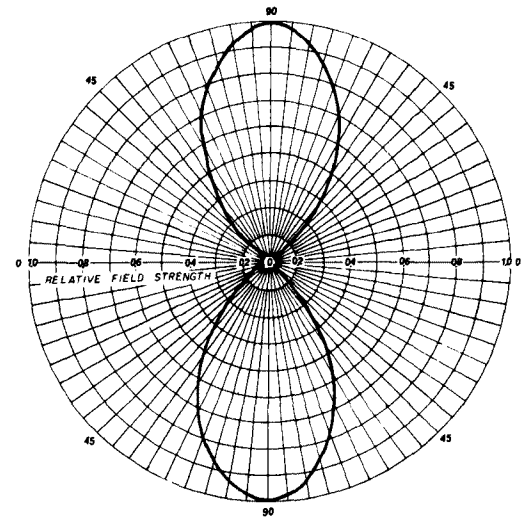


fig. 4. Radiation pattern of two collinear elements.

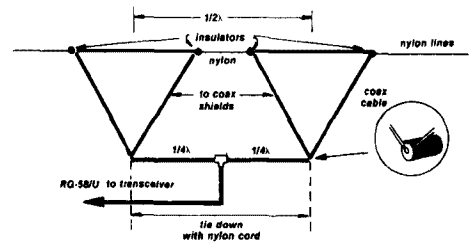


fig. 5. Another version of the phased delta array using one-half wavelength spacing.

Antennas are great fun. They are much more inexpensive than amplifiers. Let me know how you make out — I'm always interested in what my antenna ideas do for others.

One caution: if you use a really high-gain array, a polar map is essential for pointing directions. I read about a ham who put up a ten-element Bruce array, and used a regular orthogonal map and completely missed his objective.

ham radio

How to use your Amateur Radio experience to gain a career in the professional world

from Amateur to professional

By John Edwards, KI2U, 78-56 86th Street, Glendale, New York 11385

The Federal Communications Commission is quite explicit on the following point:
United States Amateur Regulations: 97.112 a) An amateur station shall not be used to transmit or receive messages for hire, nor for communication for material compensation, direct or indirect, paid or promised.

In other words, you can't make money from Amateur Radio. Or can you? Well, you can't charge fees for passing traffic, and running commercials is strictly *verboten*. However, there are legal ways of earning money indirectly from your hobby. As a matter of fact, the FCC says, in another part of its rules (*Section 97.1*), that the aims of the Amateur service are to provide an *expansion of the existing reservoir...of trained operators, technicians and electronics experts.* In the past, this section of the Amateur regulations has been interpreted by many as meaning a pool of experts available to the military in time of war, but it's obvious that such people can serve private industry as well. And Amateurs serving private industry means *jobs for hams*.

cashing in on Amateur Radio

Perhaps like no other hobby or pastime, Amateur Radio provides its participants with a real opportunity

to acquire skills immensely useful in the world of time clocks and paychecks. The fact that this training can also be lots of fun is an extra benefit. Just think of some recent ham-radio contacts you've had. Odds are that half (probably more) of the people you spoke to were employed in some type of radio or electronics-related field. Now, whether ham radio got these people interested in their jobs or vice versa is subject to debate. But the fact of the matter is that ham radio and professional electronics go hand in hand.

What this means to you is that all those hours spent poring over electronics theory books and attending licensing classes didn't go to waste the moment you received your ticket. Depending on how high up the Amateur licensing ladder you've progressed, you may be qualified for scores of jobs with only a little extra training. Other, more advanced positions, may require additional formal study; but with an Amateur Radio head start, you'll probably jump to the top of your class in no time. Whether you're a high-school student looking for a career, a person in mid life frustrated with your present job, or retired and in need of some extra income, Amateur Radio may be the pathway to your financial goal.

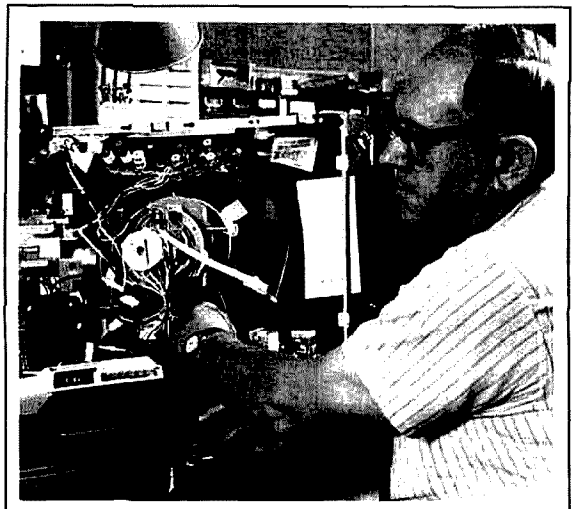
types of jobs

There are many types of occupations open to job-seeking Amateurs. The FCC, in a published list,* has counted more than 65 different career categories covering radio alone. So, contrary to public opinion, not all hams professionally employed in electronics are electrical engineers (although many are), but run the full gamut of occupations within the industry. For the purpose of this article, I've narrowed the list down to five specific fields: broadcasting, television repair, electrical engineering, computing, and two-way radio servicing. While this compilation doesn't cover the entire spectrum of jobs having an Amateur-Radio connection, it should give you a rough idea of the choices available and show how you can match your skills and interests to a specific radio-electronics career.

broadcasting

Although nearly everyone seems to have forgotten by now, at one time Amateur and broadcast radio were one and the same. Stations such as Pittsburgh's KDKA and New York's WQXR (originally, experimental station W2XR), among others, were pioneered by Amateurs fascinated with the concept of radiotelephone communications. Only when advertisers realized the potential of mass electronic communications, and began pouring money into the broadcast radio service, did Amateur and professional radio enthusiasts part ways.

*A publication called "Careers in Broadcasting," routinely sent to those writing the FCC for job information.



Television repair, either as a full or part-time job, has long been a traditional field for Amateurs. (*Photo courtesy Hewlett-Packard.*)

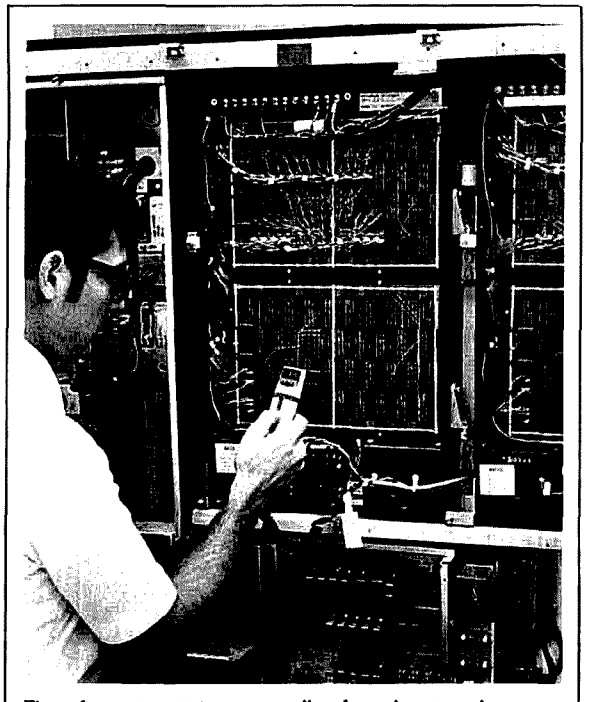
Practical experience. Even though the gap between Amateur and professional radio is now large, the distance separating the two isn't all that far. For instance, if you know how to build and operate an Amateur am transmitter, chances are you can do the same with a commercial rig. And, of course, when it comes to troubleshooting a circuit, it makes no difference whether the rig you're working



From technicians to engineers — as sex barriers continue to fall, more jobs in all areas of the electronics industry will open to women. (*Photo courtesy Hewlett-Packard.*)

on is Amateur or commercial. Actually, the greatest barrier separating technical people in the two services is the FCC. Just as the Commission has an incentive licensing ladder for hams, a similar structure also exists for broadcast engineers. To operate or service any type of commercial equipment within the United States, you must hold one of three levels of commercial radiotelephone licenses, which are designated as First, Second, and Third Class tickets. A First, in most cases, is required for broadcast station technical employment.

Technical requirements. The examinations for these licenses are rigorous (although there is some



The cbmputer, two-way radio, broadcast and many other industries have a real need for trained technicians. And many newcomers will come from the ranks of Amateur Radio. (*Photo courtesy Hewlett-Packard.*)

disagreement on whether the Amateur Extra or First-Class Radiotelephone is tougher), but not beyond the comprehension of most Amateurs. While the material in these tests is much too detailed to cover here, your local FCC field office can provide you with the latest syllabus together with an examination time schedule for your area.

While a radiotelephone ticket is necessary to get your foot into broadcasting's door, you'll probably need some outside education, too. This can include technical school, junior college and even, in some lucky cases, on-the-job training. These days, in a switch from the past, many prospective broadcast engineers are also going the four-year college route. An extra benefit here is that most schools offering a broadcasting or communications major will have a radio station and television studio available for students for hands-on experience. Such practice, besides training the student, also gives him or her a chance to decide which specific area of broadcast engineering to enter.

Compensation. Pay for broadcast engineers is good, from about $9,000 a year for a beginner at a small-town station to over $35,000 for a chief engineer at a "Top 10" market outlet. In a middle-level position, pay ranges between $15,000 and $20,000 — somewhat higher at larger, unionized stations, and, of course, the networks.* In addition, scanning the want ads in *Broadcasting* magazine (available at most larger libraries) will give you a good idea of job opportunities around the country.

television repair

The receiving end of the broadcasting industry also has ample job opportunities for Amateurs. Although being a television service technician may not sound as glamorous as working at a radio or TV station, it's still an excellent field in which to make an adequate, steady income.

Independent shop or salaried employee? There are two traditional ways to earn money from television repairs. You can either open your own shop and be your own boss, or you can become someone else's salaried employee. If you operate your own shop, there's really no simple way of telling how much income you'll make in a year. You might hit the big time and decide to start a chain of television service centers in shopping malls across the nation, or you could fail and lose everything.

Factors affecting your chances for success will hinge on the size of your shop's community, potential competition and, certainly, your own business sense and technical acumen. On the other hand, working as a technician in someone else's business offers the comforting prospects of a weekly paycheck and job security. As a tradeoff, many TV technicians with an eye toward opening their own business will opt to put in at least five years work as a service shop employee before setting off on their own. This trial period gives the budding entrepreneur time to acquire the skills of the trade while simultaneously learning from his boss's mistakes. The average $11,000-$15,000 a year such an employee can expect to earn should also help to provide at least some of the nest egg for his eventual business.

*For more information about careers in broadcast engineering, write to the National Association of Broadcast Employees and Technicians (NABET), 135 West 50th Street, New York, New York 10019.

Free lancing. Besides the two ways mentioned above, there's also a third path to making a TV servicing income that's especially appealing to part-timers — free lancing. With this method you can use your own ham-radio workbench to service TVs on a small scale in your own home. Of course, you'll have to scrounge your own customers; but by advertising in local newspapers and undercutting the high-overhead competition, you should be able to make more than a few bucks. Just be sure to fine out *in advance* if your community has any laws regulating TV repair shops.

Shoddy practices by a minority of TV technicians have forced severe crackdowns by some localities, and you'll want to be sure that you're operating within the law. But whichever route you take, if you're good at troubleshooting and perhaps have a year or two of technical-school training, TV servicing may be your answer.

electrical engineering

"If you've got the degree, we've got the job." That seems to be the rallying cry for EEs springing from virtually every major newspaper's employment pages these days. Whether you want to be a design engineer, technical writer, or consultant, it's certainly a job hunter's market with companies literally all over each other to get qualified applicants. So tight is the current EE job squeeze that many firms in California's "Silicon Valley" have even taken to building on-site tennis courts and swimming pools to attract workers.

What's available. Needless to say, with some employers even going so far as to fly applicants across the country at no charge just to look over the facilities, many EEs can almost write their own ticket. It's not unusual for someone in such especially desirable fields as microprocessor and energy work having say, five years' experience, to be earning upwards of $30,000. Not bad. But there is a price to pay for such a rosy picture; and the cost here is education — the more the better.

While a bachelor's degree is a must, the ever-increasing flood of technical information swamping the industry is making engineers holding masters degrees and even doctorates especially sought-after. Of course, you'll have to pay to get that education; but with the salaries currently being offered, you should be able to make the money back quickly. Many firms will even refund your education costs as a bonus for signing up.

Using your ham experience. Obviously, a ham ticket isn't as important here as it might be in broadcast engineering or TV servicing. Just because you passed a few FCC exams doesn't mean you can design an aircraft radar system. Yet, Amateur experience can be a big boost to your education. The mere fact that you hold an Amateur license is evidence of your interest in the field. While it may not be your only key to success, it will give you a leg up on the competition. And when it comes to the tough schooling an EE needs, every bit of an advantage helps. Anyway, who knows? With your Amateur Radio background, someday you may even get a job designing ham rigs!*

computing

As in electrical engineering, the job situation here is pretty wild. Although employers won't go to quite the same lengths to get qualified computer people as they do for EEs, the money is tops, the job market very open and, perhaps best of all, you won't have to spend six or more years at college to get started.

Depending on the exact area of computing you're contemplating, you may be able to get away with as little as a year or two at a technical school or junior college. Data processing and computer maintenance are just a couple of areas open to applicants with as little as a few months of classroom training. Of course, for higher-level positions in such areas as programming or analysis, you'll need a four-year college degree; but, as in electrical engineering, the financial rewards are substantial, so an educational investment can be most worthwhile.

Although the computer field isn't directly related to Amateur Radio, many hams do manage to combine the two. Just ask your friend who spends his weekends swapping programs, through ASCII RTTY, on 2 meters.

So, if you're the type of person who can't enjoy getting on the air without a keyboard at hand, you may be able to enter the computer field without any additional schooling at all — or you can finance your advanced education by working at a part-time computer job.

Depending on your exact skills, many openings exist for computer operators and program troubleshooters with virtually no knowledge of computer electronics but requiring a deep understanding of computer languages, something many advanced computer hobbyists seem to possess almost by second nature. Also, most companies specializing in games and other personal-computer software are constantly searching for people who can supply them with new and interesting software. So take a look around! If you regularly operate a home computer, chances are there's a job waiting for you somewhere.

*For more information on electrical-engineering careers, drop a line to the Institute of Electrical and Electronics Engineers (IEEE), 345 East 47th Street, New York, New York 10017.

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two-way radio servicing

A long-time career choice for many Amateurs, the two-way radio servicing business is experiencing something of a renaissance. An explosion in two-way radio use, combined with a serious drought of expert technicians, has created an ever-widening demand for skilled people to repair everything from police radios to CB sets.

Since two-way radio technicians (like their broadcasting counterparts) must make transmitter repairs, workers here are required to hold an FCC radiotelephone license. On the brighter side, however, only a Second-Class ticket is usually needed for most two-way equipment servicing.

Pay for these radio technicians is superb, especially when you consider that a reasonably intelligent Amateur holding a Second-Class commercial license doesn't need anything more than a basic high-school diploma to begin his career. Such a person can expect to make around $10,000 a year to start, with salary prospects going as high as $25,000 for a supervisory position, and even more for repair-department heads for such major employers as the airlines and government.

Uncle Sam

Speaking of the government, many good opportunities exist within Civil Service for radio technicians. Federal, state and local governments are in almost constant need of qualified people to repair and maintain radios for police, fire, safety, and other public services. For the latest line on government jobs in your area, write to your state or local Civil Service department.*

By the way, if you feel you can't drag your interests too far away from Amateur Radio, the U.S. Office of Personnel Management will also send you information on how to apply for a job with the FCC. Now, there's a job with a real Amateur-Radio connection!

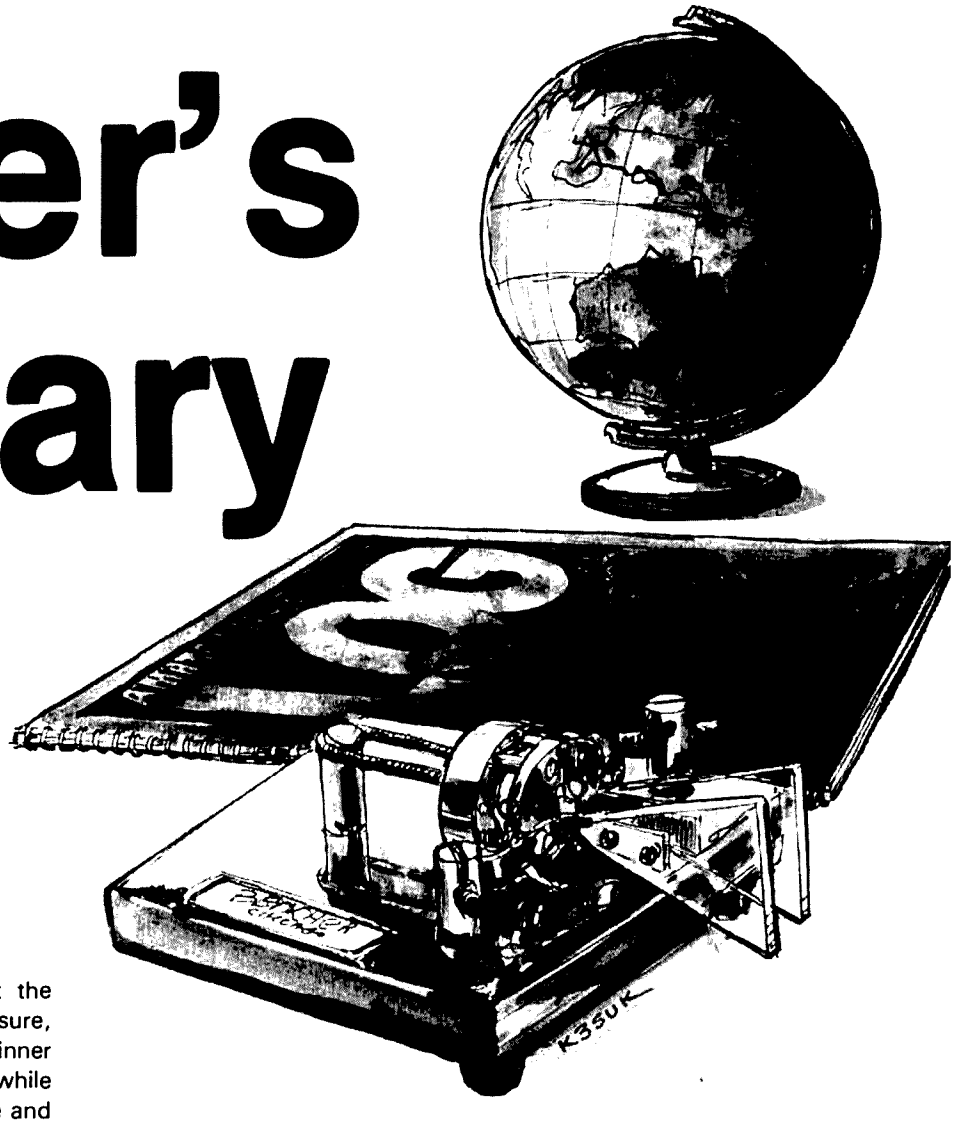
final comments

So put your Amateur-Radio skills to work. There's a big, wide world out there crying for people with your technical knowledge, and they're willing to pay good money for what you learned from those study manuals. One last word: when applying for a job, be sure to mention *Amateur Radio* on your resume or application. More than one ham has been pleasantly surprised when that imposing person interviewing him or her for a job suddenly looked up from the form, smiled, and said, "Say, I'm a ham, too."

*If you're interested in working for the federal government, contact the U.S. Office of Personnel Management, 1900 E. Street Northwest, Washington, D.C. 20415, for details on Civil Service applications and examinations.

ham radio

DXer's diary



By Bob Locher
W9KNI

I arrive home from work at the usual time. It was a full day for sure, and I'm a bit tired. But a good dinner — and a chance to relax a bit while reading the paper — refresh me and I'm ready to go. By 0030 Zulu, 7:30 Central Daylight Saving Time, I'm easing into the operating chair.

I flip the switches to turn on the gear and move the bandswitches to 15 meters. With the elevated sunspot count these days, 15 is queen of the DX bands during late summer. Usable during the day for DX, it really comes alive in the late afternoon and early evening, and probably will stay open all night if conditions are any good at all.

I'm hoping that LU3ZY will show up again tonight. This station is run by the Argentine Navy from the exceedingly rare South Sandwich Islands. Until this station became operational recently there had been no activity from these islands for over ten years, the last operation having been put on by a British VP8 station.

The islands harbor an environment hostile to man. The small group is actively volcanic, and a volcanic eruption in fact caused the emergency evacuation of a scientific team a few years ago. The island group is claimed by both Argentina and the United Kingdom, but neither party seemed too concerned about the matter until international law developed the concept of 200-mile zones of economic control around islands such as the South Sandwiches. Suddenly, these deserted, remote, Antarctic islands became the sacred soil of the motherland, with both Argentina and Great Britain heatedly arguing their claims.

But the DXCC program recognizes operation from either country, and I will be perfectly content to receive a QSL from either LU3ZY or a VP8, as long as it says, "South Sandwich Islands" on it.

I bring the antenna around to 151 degrees, the bearing my *Second Op* says is correct for the American Midwest bearing to the South Sandwiches, and I begin tuning the band.

LU3ZY is proving to be an elusive catch. I have heard him twice this summer, once on that memorable night when I snagged the A51 in Bhutan (the thought still brings a grin to my face — sure hope the QSL shows up soon), and I heard him again three weeks later, again on 15 CW. A YV station told me that he was often on

10 meters, but that won't do us much good in the Northern Hemisphere in summer. Openings are possible, but unlikely that far into the Antarctic.

The *DX Tip Sheet* shows that he has been operating a little on 20 meters: at 5 AM local one night, 2 AM another. I'd get up and watch for him if he would ever show a pattern; and I did stay up till 2 AM one night with insomnia. Sure enough, not only did he get on at 5 AM that morning, but when he did, he QSO'd VK9NV, the Norfolk islander that I still need. Aggh!

I just have not been able to get a pattern on him. And maybe there isn't one. Most DX stations have a pattern, and if you can get enough data, it usually is pretty easy to find the fellow, often requiring nothing more than a little bookkeeping and a little lost sleep. Of course, working him after you find him can be another thing, especially if lots of other hungry DXers also know the DX station's pattern.

But some fellows just don't follow a pattern, and they are the kind that give you grey hair. I've got a bit of help lined up: K6NA and I have a pact to call each other if we hear the LU3. Glenn is two hours behind us, so he'll be up later, which helps; and besides, I don't think he ever sleeps. With the score that he's got, he couldn't.

The band tonight seems in good shape. As I tune up from the bottom, strong signals from South America seem everywhere. There aren't all that many CW stations in South America but the ones you do find are superb operators, almost to a man.

But it's not South Americans that I'm after, it's the Antarctic islands. I keep tuning, listening especially for signals that are a little weaker. Of course, most of the signals that are a little weaker are from stations using low power and simple antennas, or they are stations coming in off the back or the sides of my antenna. But, in any case, there are lots and lots of South and Central American signals to filter through, and always the necessity of watching them to be sure one isn't a CE9 or an LU/Z station.

I tune the band slowly and carefully, but without result. I hear VP8s; all in the Falklands. I hear one of the Russian 4K1 stations in the Antarctic. There's a pretty good pileup on a PYØ, but it's Fernando de Noronha, an island off the Brazilian coast and one I don't need.

Almost before I know it, it's 0300Z, 10 PM local, time to close up shop. I muse on the evening's DXing as I head up the stairs to catch the news. Nothing at all to show, really — which, of course, is the way it is most of the time. But it was still enjoyable, listening to the world talking. And I'll be back tomorrow.

August 8th

I start tuning about the same time as last night, with the same results as last night too. Lots of South Americans; little else. Band conditions don't seem to be as good. Maybe tomorrow.

August 10th

I couldn't get on the band last night. I had to stay late at work and got home late. Got to watching the game on TV during dinner and decided to stay with it, since it was already 9:30. The Cubs won again; their sixth straight on the road. LU3ZY was probably working all comers and having to call CQ to raise a little action, the way my luck runs. But the 2-meter DX net was quiet, and no phone calls. Maybe it's tonight instead. I can always hope.

The band sounds a little better tonight. I barely lift the receiver above 21,000 when I hear FB8YC calling CQ. FB8Y is the French Antarctic, a curiosity station. A lot of DXers would given up next year's vacation for FB8W, which is Crozet, and FB8X and FB8Z are almost as rare; FB8Y counts as Antarctica, which is fairly common. But again, the station is on the Indian Ocean side of the Antarctic continent, so it is a long shot over a transpolar path to a station whose existence is widely know, but one that is rarely heard.

I bring the VFO up on him. He signs, and, pausing a second, I hear several stations start calling him. I call, but when I open the receiver again, I hear him calling W1FB. Regretfully, I decide to move on. I



don't need him for a country counter, and I do need the LU3ZY QSO. If I could have nailed him quick and easy, I would have, but I can't. Maybe later, after I've had a look across the band, I'll find him without a pileup. If I do, I'll try again.

With that behind me, I continue tuning up the band. It quickly becomes apparent that conditions are pretty good, with lots and lots of signals. Hey, there's a bit of a pileup. OK, it's 8R1G. And the pileup on him is mostly JA stations; some of them are pretty loud, and off the back of my antenna at that.

At 21,033 kHz, I run across ZD8TC negotiating his way through a crowd of admirers in contest style. And three kHz above him is VP5FM. And everywhere are South Americans; PYs, LUs, plus the occasional CE, ZP, and CX.

There's a weak signal calling a CO. OK, another JA. And there's KC4AAF, one of the American scientific stations in the Antarctic. Well, the band's open, for sure. I decide to speed up my tuning for a few minutes, and use that old Novice technique, "tune for the pileup."

Normally, I never use this technique on purpose. I much prefer to crawl up a band, listening to every signal at least for a moment. It's a heck of a lot more productive, and frankly, a lot less boring. In fact, it's fun, even if I don't catch a new one. A good open band is a dynamic, living thing, with a possible surprise at every kHz: to hear a band, to explore it, to hear signals from everywhere on different paths, to eavesdrop on old friends chatting or people making new friends.

Careful tuning brings other thrills, too. Digging a really rare one out, getting him in a one-on-one situation, having a nice ragchew with liberal use of his callsign — and then the enormous pileup on him when you sign clear with your 100 watts — it's heady *stuff*.

Tuning for pileups is a great way to run up an SWL DXCC, but getting the QSO can be tough, really tough. Especially when you're after a rare one. Still, suppose that the LU3ZY station is already on the band? A half hour's careful tuning from the bottom up that leads to finding him at 21,080 with a horrendous pileup isn't necessarily the right way to do it either.

I start tuning higher, but much more rapidly. Instead of individual signals, I look for concentrations of signals; in a word, for pileups.

At 21,057, I find one. I should say centered on 057. This one's huge; hundreds of stations frantically calling; but calling whom? The calling stations seem to be spread out a bit, over at least five kHz. That's a pretty good sign that whomever they are chasing is working split frequency. And yes, they all start calling at once, and they all stop calling at almost the same time.

Whoever's running this pileup is a real pro; he's got everyone marching to his drumbeat. And the way they are calling so neatly in unison suggests that he has a pretty loud signal. He's probably lower in frequency; I drop back to 21,050 and have a look.

Almost immediately I find him; a good 579 signal, really pounding it out:

"W1DA 5NN K" . . . "R TU"

"4SMX ? 5NN K" . . . "R K4SMX EE"

"N4AR HI BILL 5NN K" . . . "CU E E"

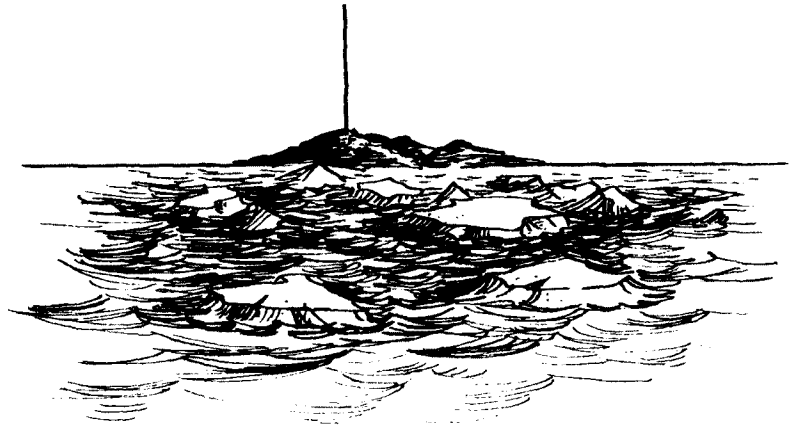
"PY7PO 5NN K" . . . "R QSL VIA KØHGB QTH SO GEORGIA 73 DE VP8MU QRZ UP8"

South Georgia. A real goody indeed, and one I don't need, but that's another story. I call it on 2 meters; "VP8MU, that's Victor Pappa Eight Mexico Uniform, South Georgia, twenty one oh five oh, South Georgia, twenty one oh five oh, listening up eight, he's got a good signal, here's W9KNI."

I get a terse response: "All right!" Hmm. Whoever that was really should sign a call. Oh well.

Anyhow, it's time to keep moving. I'm soon up to 21,150 and, as I suspected after hearing the South Georgian pileup, no LU3ZY. In a non-contest situation, it's rare to have two or more huge pileups on a band. If nothing else, two rare stations split the band population between them, limiting the size of either pileup.

Anyhow, it's back to slow, careful tuning for me, now that I'm pretty confident that the LU3ZY station isn't a featured guest in a pileup. I move the receiver back down to the bottom of the band and start tuning up higher again. My interest is heightened now, helping me to keep the concentration needed for the job at hand. Hearing that VP8 on South Georgia has gotten my fires lit, even though I don't





need him. After all, South Georgia and the South Sandwich isles are neighbors in that frozen part of the globe. Maybe there is hope. The band is open, at least, and that pileup is so huge that there can't be too many people after LU3ZY if he does show.

Another factor is in my favor. It's summer here and winter there: the long night of the polar regions, and so cold that the personnel at the station have to pretty well stay inside. Maybe there's a shortage of entertainment; operating 15-meter CW could be an ideal pastime.

I tune much more carefully this time, more the way I prefer to tune. If I didn't have a specific target (that is, the LU3) I would tune through 100 kHz, then rotate the antenna 90 degrees and do it again. If the band is open at all, it can be a fascinating exercise, listening to the world. I listen to this signal, "QTH HR BUENOS AIRES," and that signal, "QSL SURE VIA BUREAU," obviously a statesider with backscatter, and if he is going to QSL via the bureau he obviously isn't too excited.

Then, another backscatter statesider, "OK ISIDRO QSL VIA LU2CN TNX NEW ONE ES 73 . . ." That almost has to be him! The right name, the right manager, and a new country for whoever's in QSO. I punch the switch to turn on the linear. Bzzzt — zap — the surge relay drops out, and it's operational. It's already tuned on 15; I only need to trim the drive level from the exciter. I back off the drive control on the exciter; I will advance it to the proper level as I start my call.

There — the other station is signing — sure enough, "LU3ZY DE W3KT SK." I listen intently. There he is, almost dead on 3KT's frequency.

"R W3KT DE LU3ZY OK OM TNX ES 73 MUST QRT FOR DUTY W3KT DE LU3ZY SK CL EE."

Arrrhhhgh! Ohhhhgh!

I call, desperately, a one by two. I listen. Nothing. Absolutely nothing; no competition and no QSO. I call again, but I know I'm dead. I listen. I'm right.

After a pause, I hear, "SRI HOPE U GET HIM NEXT TIME W9KNI 73 DE W3KT" That KT's a gentleman, a class act.

I respond, "R TNX JESSE ES CONGRATS UR FINE CATCH 73 ES GL W3KT DE W9KNI EE."

Gad. Maybe I should go back to stamp collecting.

But even as I consider such options, I make notes on my little chalk board, "LU3ZY 21032 0154Z." I make a mental note as well that the slight chirp he appeared to have last time I heard him seems to be gone; his signal was nice and clean this time. Hmmm. The time is interesting. Obviously his watch must change at 0200 Zulu, so that he has to go on duty, and QRT. I'm pretty sure that he could not have been on the band long, or there would have been a terrific pileup on him. I wonder how W3KT caught him? On a CQ maybe? Or hunting? 3KT's a sharp old fox, and his QSO with the LU3 was probably no accident. He knew what he was doing.

Well, I don't really have enough data to mark any kind of a trend, although I have a good deal more than I did yesterday at this time. But you better believe one thing — I'm going to be watching tomorrow around 21,032 at 0130Z like a hawk.

I turn off the gear and head up the stairs. Might as well go for a walk.

August 11

I had to work late again tonight, but still, I managed to get home in good time. My wife, sympathetic to the cause, has dinner ready when I get home, and I'm in front of the rig with a few minutes to spare against my self-appointed schedule.

OK. Antenna south-southeast. Check. Linear tuned for 15. Check. Attenuator out. Check. I settle the headphones into place, bring up the receiver gain — and there he is, square in the middle of the passband.

"CQ CQ DE LU3ZY LU3ZY AR K.



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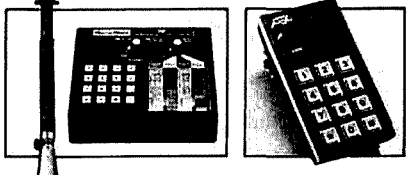
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Bzzzt. Snap, the linear's on. I pause a moment as I back down the exciter drive level control. Ahh, no one else seems to be calling, as I yank the VFO dead on him. I start calling him and quickly bring the drive up as I go. I can't believe it; this is all happening so fast I haven't even had time to get excited or get butterflies yet. "LU3ZY DE W9KNI W9KNI AR K." I open the receiver without yet having to touch the receiver dial from where I left it last night.

Huh! There are two signals calling me! Hah! Yes, one is the LU3ZY station. OK, the other's an LU2. Guess he thought I was signing from a CQ. I ignore him.

"KNI DE LU3ZY R GE OC ES TNX QSO UR RST 589 589 NAME HR ISIDRO ISIDRO QSL VIA LU2CN LU2CN HW CPY W9KNI DE LU3ZY KN."

How sweet it is! "R LU3ZY DE W9KNI FB DR ISIDRO ES TNX NEW COUNTRY RST 579 579 HR NR CHICAGO NR CHICAGO ES NAME BOB BOB QSL SURE LU2CN OK? LU3ZY DE W9KNI AR."

"R FB BOB QSL SURE ES GLD BE NEW FOR U 73 ES GOOD DX W9KNI DE LU3ZY SK QRZ? K."

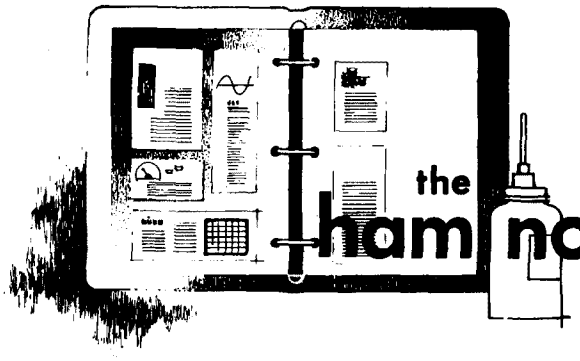
As he starts the QRZ, I shove the headset back, grab the telephone, and start punching digits. Let's see. It's almost 7 PM out there on the Coast; Glenn should be home by now. The phone rings, but no answer. I pull the headphone jack out to activate the speaker, and desperately start dialing again.

But wait! "HOW CPY? K6NA DE LU3ZY AR KN." Hah! No wonder the phone went unanswered.

"OK GLENN TNX QSO MUST QRT FOR DUTY 73 ES GL K6NA DE LU3ZY SK CL EE."

I keep listening. Sure enough, a couple of stations are calling, but I know how well that is going to work out. I swing the antenna around to the west. "K6NA UP 2 DE W9KNI." Glenn responds with a brief "R" and we go up for a very happy ragchew.

ham radio



the ham notebook

squirrel-cage motors make field-day power supplies

One of the perrenial deterrents to portable and field Amateur Radio operation is the cost of a suitable energy source. Small gasoline engines can be had quite reasonably priced from lawnmower shops and Goodwill as-is stores, to name but two of many sources, but generators that produce 115 volts at 60 Hz are a scarce and expensive *commodity*. Or are they?

Used washing-machine and dryer motors are easy to come by. Goodwill, Salvation Army, and other used-merchandise stores, or scrap-yards, sell such motors for from $2 to $5; most often you have to take the washing machine and do the salvaging yourself. Motors? But it's an alternator we need for the field power unit, not an electric motor!

the motor as a generator

Fractional and multi-horsepower motors operate quite well as ac generators. Coupled to a suitable gasoline engine and driven at approximately the same speed at which they run as a motor, they will deliver alternating current power almost as well as an alternator designed for the job, and without any rewinding whatsoever. All that is needed is a little know-how and a willingness to tinker, plus a careful curbing of the standard ham tendency to overload equipment.

Washing-machine motors are generally rated at 1/4 to 1/3 hp and an occasional one may be found at 1/2 hp. These are supplied with resistance-starting, phase-splitting windings. **Fig. 1** shows a typical example. Dryer motors are rated from 1/6 to 1/3 hp, and are as likely as not to be capacitor split-phased, sometimes just for starting, but occasionally for

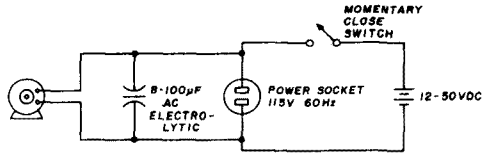


fig. 1. Split-phase-start motor.

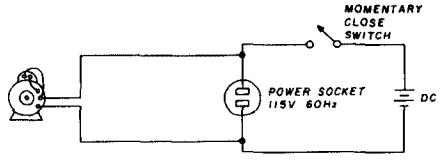


fig. 2. Capacitor-run motor. Additional capacitor is not needed.

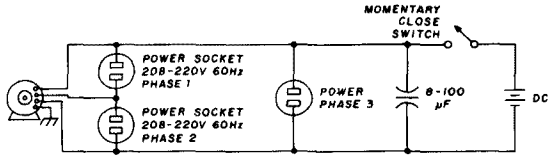


***fig. 3.* Three-phase, 3-wire delta *motor.* If this motor is used as an alternator in this manner, keep in mind that 220 V exists between two pieces of equipment plugged into the three-phase outlets! Even though 120° out of phase, it can deliver an unpleasant shock and can cause undesirable ground loops.**

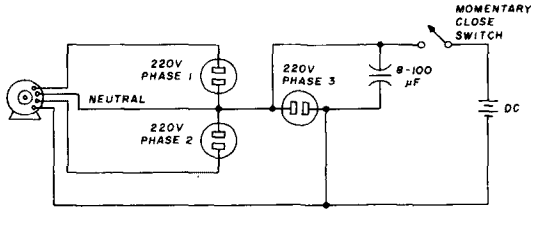


fig. 4. Three-phase, 4-wire star-connected motor. The note in *fig. 3* applies to this alternator as well.

unning as well. The key to coaxing a squirrel-cage motor (virtually all large-appliance, fractional-hp motors are his type) to perform as an alternator s in the use of capacitance to supply a field voltage.

split-phase-start motor

Without going too deeply into motor theory, a capacitor placed across the power leads of a motor creates a split-phase condition in the motor windings, which produces a resonance between the inductance of the winding and the induced current n the rotating squirrel-cage armature. Within certain power limits, the motor will perform as an alternator. Because such motors are "induction" motors with a 5 per cent slippage factor, the squirrel-cage must rotate about 5 per cent faster than synchronous speed to produce 60 Hz: a motor rated at 1750 RPM would have to be turned at 1890 RPM to obtain 60 Hz (synchronous speed: 1800 plus 5 per cent).

Sometimes such a motor used as a power source will start to deliver current by itself as it comes up to speed. Frequently, however, it is necessary to supply a momentary dc pulse to the motor windings to induce magnetic-field poles into the soft-iron armature. This pulse may be applied either before starting the engine, or after the motor has come up to speed. If the latter, it is obvious that the pulse should be just that — a *pulse*, because the dc source becomes a short circuit to the alternator output the moment power generation begins.

Such an alternator will not produce as much power as the labeled motor rating, for two or more reasons: efficiency losses, power-factor losses, and perversity. The latter, which seems somewhat facetious, will be found to hold quite true in practice.

capacitor-run motor

A split-phase, capacitor-run motor will not need an additional capacitor (fig. 2). It is ready to operate as an alternator with only the occasional need for a momentary dc starting pulse. A resistance-start, split-phase motor will require from 8 to 100 μF across the power terminals; final size to be determined by cut-and-try. Ac-rated electrolytic capacitors should be used, obtainable from motor-rewinding shops, although standard dc electrolytics may be used by connecting them in series, back-to-back. Choose at least 300-volt ratings, as electrolytics must be derated for use in power ac circuits. The capacitance of a back-to-back combination is the capacitance of one — they are not additive or subtractive in this circuit. The momentary starting pulse may be applied through a simple touch-switch circuit from a 12-volt automobile battery.

three-phase machines

Larger squirrel-cage motors are sometimes available from discarded power-shop equipment. Table saws, planes, and sanders use motors rated from 3/4 to 2 hp, usually capacitor-run variety. Even larger motors are used for water pumping and many industrial demands, but usually are three-phase types (figs. 3 and 4). These are equally useful as alternators, but the output is three phase, although single phase across any two legs (except when four wires — see fig. 4). The voltage, however, is usually either 208 or 220 volts across each leg. When used as an alternator, it is necessary to parallel only one leg of the three with a capacitor.

It is almost impossible to burn out a squirrel-cage motor operating as an alternator. An overload will null the rotating field, and the alternator will simply cease to generate. Generation can be started again by a pulse of dc across the output leads. It may therefore be advisable to breadboard a power supply before building it into a fancy metal frame, to make sure that the motor (alternator) is large enough to supply the rig plus a small-wattage bulb for nighttime log-keeping or whatever. For test, parallel a number of bulb sockets and screw in one bulb at a time. Add to the load until the alternator suddenly ceases to function. The sum of the bulb wattages is your absolute top output power.

Walt Boyd, K6DZY

glossary of terms

induction motor — An ac motor featuring a primary power winding (usually the stator) and a unique "squirrel-cage" secondary (usually the armature). Currents, and therefore magnetic poles, are *induced* into the secondary by the rotating primary magnetic field; thus the armature rotates at slightly slower than synchronous speed, called "slip." The amount of slip increases with an increase in mechanical loading.

split-phase motor — Single-phase induction motors are not self-starting. They are momentarily converted to two-phase (polyphase, self-starting) motors by inclusion of additional primary power windings displaced 90° from the main windings. Occasionally the auxiliary windings are designed to operate full time rather than momentarily.

resistance-start motor — A split-phase induction motor employing a resistive auxiliary starting winding (copper alloy or iron wire) to shift the phase angle approximately 90°. Used almost exclusively for low-starting-power requirements, this winding is switched out of the circuit when the armature approaches near-synchronous speed.

capacitor-start motor — When greater starting torque is required for a split-phase induction motor, a capacitor is used in series with the auxiliary starting winding to provide a leading current vector of 90°, which momentarily converts the motor to a polyphase induction motor.

capacitor-run motor — A single-phase induction motor using a capacitor in series with a second primary winding displaced 90° from the first. This winding remains in the circuit full time, converting the machine to polyphase operation.

three-phase motor — A true polyphase induction motor with three or more power windings designed specifically to operate from a three-phase power source. It is self-starting.

synchronous motor — A motor that runs at a speed in step with the power-station frequency (fundamental or harmonic of the alternator speed). Often started as an induction motor and converted to synchronous operation as it approaches synchronous speed.

universal motor — A motor with wound field and armature, with commutator to make dc operation possible. When all windings are connected in series-aiding, it will operate on ac as well as dc, although the higher the ac frequency the more carefully the iron must be laminated to prevent excess eddy-current heating loss.

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The Gunnplexer Cookbook, 16 chapters, 335 pages, softbound. Published by The Ham Radio Publishing Group, Greenville, New Hampshire 03048. Price: $9.95 plus $1.00 shipping and handling.

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ALABAMA: The Central Alabama Amateur Radio Association's 4th Annual Hamfest, Sunday, September 13, Civic Center, downtown Montgomery. Free admission; free parking. Air-conditioned Flea Market. Set-up 0600. Doors open from 0800-1500. Prize drawing 1400 CDST. Restaurants and motels within walking distance of Civic Center. Refreshments available. Talk-in on 146.04/.64 or 146.52/S. For information or reservations: Hamfest Committee, PO Box 3141, Montgomery, AL 36109.

ALABAMA: The Huntsville Hamfest (formerly the North Alabama Hamfest), Saturday and Sunday, August 15 and 16, Von Braun Civic Center, Huntsville. Free admission. Prizes, exhibits, forums, air-conditioned indoor flea market and ladies' activities. Flea market tables $3.00/day. Family tours of the Alabama Space & Rocket Center available. Limited camp sites with hookups. Talk in on 3.965 and 34/94. For information: Huntsville Hamfest, PO Box 4563, Huntsville, AL 35802.

ARIZONA: The Scottsdale Amateur Radio Club, Inc. will host the 1981 Southwestern Division ARRL Regional Convention, October 9-11, Ramada Safari Resort in Scottsdale. Talk-in on 146.52 and 147.84/24 MHz. Further information: S.A.R.C. Convention Committee, PO Box 3073, Scottsdale, AZ 85257.

CALIFORNIA: The Tri-County Amateur Radio Association's annual Hamfest, Saturday, August 8, 9 AM to 3 PM, Los Angeles County Fairgrounds (Thummer's Patio). No charge. Bring a picnic lunch. Refreshments available. A noon raffle is featured. Grand Prizes: Quasar 10" TV; Tempo S-1 Hand-Held. Winner must be licensed Ham but need not be present. Donation: $1.00. Talk in on 146.34/94. For information: TCARA, PO Box 142, Pomona, CA 91767.

DELAWARE: The Sixth annual New Delmarva Hamfest, Sunday, August 16, Gloryland Park, Bear. 8 AM to 4 PM. Admission: $2.25 advance; $2.75 gate. YL and jr ops free. Tailgating or covered table space $3.50. Refreshments available. First prize: ICOM IC-2A and many other prizes. Talk-in on 52 and 13/73. For tickets, map, info: SASE to Stephen J. Momot, K3HBP, 14 Balsam Rd., Wilmington, DE 19804.

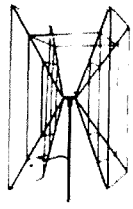
GEORGIA: Augusta Amateur Radio Club's annual Hamfest will be held September 20, 1981, at the Julian Smith Casino. Prizes will be a DenTron Clipperton L, a Cushcraft A4 Tribander, and an Icom IC2A. Bingo for the family. Talk-in 34-94. Tailgating $3.00 includes one ticket. Tickets $1.00 each. Further information call Diane, WB4YHT, (404) 860-3700.

ILLINOIS: Illiana Repeater Systems 12th annual Danville area Hamfest, September 5 and 6, Georgetown, Illinois, Fairgrounds. Flea market, free parking, forums, family entertainment, many prizes and more. Gates open at 6:30 AM. Talk in 22/82 and 146.52. Tickets: $1.50 advance, $2.00 gate. For more info: Lowell Wells, WD9AFG, Hamfest Chairman, RR 3, Box 215, Danville, IL 61832. (217) 759-7580.

ILLINOIS: Radio Expo '81 sponsored by the Chicago FM Club will be held, rain or shine, on September 19th and 20th at the Lake County Fair Grounds, routes 45 and 120 in Grayslake. Grayslake is 30 minutes north of Chicago and 45 minutes south of Milwaukee. This year we will have a super large flea market with plenty of indoor and outdoor space, free with a gate ticket. Just bring your own table and chair or tailgate it. Parking is free. We will also have new camping sites complete with power hookups. There will be Ham seminars both Saturday and Sunday. YL's have a ladies program and door prizes both

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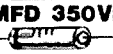
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ILLINOIS: State ARRL Convention and annual Hamfest sponsored by the Fox River Radio League, Sunday, August 23, Kane County Fairgrounds, St. Charles. Forums on antennas, DX and ARRL operations, contests and demonstrations. Advance tickets $1.50, $2.00 at gate. For tickets and information: SASE to Jerry Frieders, W9ZGP, 1501 Molitor Rd., Aurora, IL 60505. Commercial exhibitors contact Mike Pittard, KA9EVT, (312) 896-7383. Talk-in on 146.940 MHz.

ILLINOIS: Peoria Area Amateur Radio Club's Peoria Superfest '81, September 19 and 20, Exposition Gardens, W. Northmoor Rd., Peoria. Gate opens 6 AM, commercial building 9 AM. Admission: $2.00 advance, $3.00 gate. Forums, Amateur/ computer product displays, flea market, Ladies and children's programs, camping facilities. Saturday night smorgasbord, Heritage House, 8209 N. Mt. Hawley Rd. Movies at hamfest site. Talk-in on 146.16/76, call W9UVI. For information and reservations: Superfest '81, 5808 N. Andover Ct., Peoria, IL 61615.

SOUTHERN ILLINOIS: Shawnee Amateur Radio Association's 25th anniversity Silver Jubilee Hamfest will be August 30 at JOHN A. LOGAN College in Cartersville, Illinois. Offerings include Air Conditioned Flea Market — Prizes — Forums — Computers — Food — Refreshments — Contests. For details QSL Bill May, KB9QY, 800 Hilldale, Herrin, IL 62948 or (618) 942-2511 days.

INDIANA: The Bloomington Area Amateur Radio Hams will hold their 4th annual "Hoosier Backyard Hamfest," Sunday, September 6, 7 AM to 5 PM, 2335 Vernal Pike, Bloomington. Admission: $2.00. Door prizes, swap'n'shop, vendors, tree set-ups, balloon rides, 50/50 drawing, refreshments, ATV demonstrations. Grand prize: Aptron Lab ATV Converter. Rain or shine. Talk-in 7.78/18, 04/64, 233.26/224.86. For information: Bob Myers, K9KTH at above address or call (812) 332-2433.

INDIANA: The Tippecanoe Amateur Radio Association's 12th annual Hamfest, Sunday, August 16, Tippecanoe County Fairgrounds, Teal Rd. and 18th Street, Lafayette. Grounds open 7 AM. Talk-in on 146.13/73 or 146.52. Flea market, dealers, fun and prizes. For tickets and information: J.B. Van Sickle, K9KRE, RR 1, Box 63, Westpoint, IN 47992.

MINNESOTA: The St. Cloud Amateur Radio Club's Hamfest, August 9, 8 AM to 4 PM, Whitney Senior Center, St. Cloud. Swapfest, prizes, refreshments. Talk-in on 146.34/94. For information: Mike Lynch, KA0HQS, 2115 First Street South, St. Cloud, MN 56301. (612) 251-2297.

MISSOURI: The St. Charles Amateur Radio Club's Hamfest '81, August 23, Wentzville Community Club. Admission $1.00 per car. Advance tickets: $1.00 each/ 4 for $3.00. At door: $1.50 each/ 4 for $5.00. Prizes, contests, flea market, fun for all. Air conditioned exhibition building. For tickets and information: SCARC Hamfest '81, c/o Bill Graham, 512 Bermuda Dr., O'Fallon, MO 63366.

NEW JERSEY: The Sussex County Amateur Radio Club's third annual hamfest, SCARC 81, Saturday, September 12, Sussex County Farm and Horse Show grounds, Plains Rd. off US Highway 206, Augusta. Outdoor flea market sellers: $4.00 pre-registered, $5.00 gate. Indoor sellers: $5.00 pre-registered, $6.00 gate. Registration: $2.00. Door prizes. For information: Sussex County Amateur Radio Club, P.O. Box 11, Newton, NJ 07860 or Lloyd Buchholtz, WA2LHX, 10 Black Oak Drive, Vernon, NJ 07462. Talk-in on 147.90/30 and 146.52.

NEW YORK: The Suffolk County Radio Club's ARRL supported 4th annual electronic flea market, Sunday, September 13, (rain date — September 20) Odd Fellows Hall, Jayne Blvd., Port Jefferson, L.I. Gates open 7 AM. Sellers — $3.00 — one car, one driver. Walk-ins $1.50. No charge for XYL's and Harmonics of attending Hams. Bargains, prizes, food and Hamship. Talk-in on 2 meters .52 and .94, 223.5 MHz. For details: Floyd Davis, 516-234-9376.

NEW YORK: HAM-O-RAMA 81, Friday, September 18, 6 PM to 9 PM, Saturday, September 19, 7 AM to 5 PM, Erie County Fairgrounds, south of Buffalo. Outside/Inside Flea Markets, Equipment displays, technical programs, women's programs and more! General admission for both days: $3.00 Advance, $4.00 gate. Refreshments available. Talk in on W2EUP/R 146.31/91. For information: Nelson Oldfield, 126 Greenway Blvd., Cheektowaga, NY 14225, 634-6394 or Mike Merrick, 419 Sommerville Avenue, Tonawanda, NY 14150, 835-0866.

More Details? CHECK—OFF Page 94

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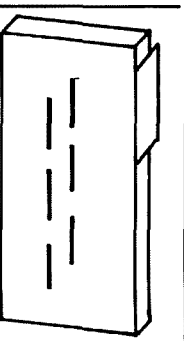
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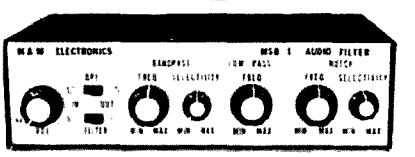
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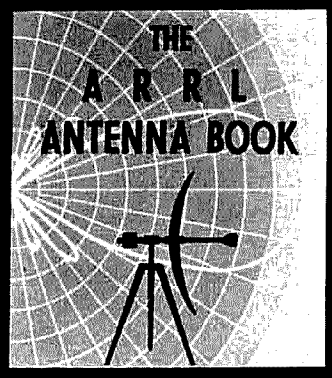
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NEW YORK: The Seaway Valley Hamfest, Saturday, September 12, Municipal Arena, Louisville, near Massena and the St. Lawrence Seaway. Activities include flea market, commercial exhibitors, movies, magic show, snack bar and more. For information: Louis G. Ierlan, WA2RXO, Secretary, Seaway Valley Hamfest Committee, 725 Proctor Avenue, Ogdensburg, NY 13669.

NEW YORK: The Hall of Science ARC's Sixth annual Hamfest, September 13, from 9 to 4, Municipal Parking Garage, one block north of Queens Boulevard, 80-25 — 126th Street, Kew Gardens. Sellers, $3.00; Buyers $1.00. Refreshments, free parking. Talk-in on .52. For information: Tom Doyle, KA2DTB (212) 738-8887 or (212) 641-1700.

OHIO: The Original Forty-fourth Annual Hamfest, Sunday, September 20, 1981, at Stricker's Grove on State Route 128, one mile west of Venice (Ross) Ohio. Exhibits, prizes, food and refreshments available. Flea Market (radio related products only), music, talks, hidden transmitter hunt and sensational air show. Admission and registration $4.00. For information: Lillian Abbott, K8CKI.317 Greenwell Road.Cincinnati, Ohio 45238.

OHIO: The 24th Annual Warren Hamfest, August 16, Kent State Branch, Trumbull County, Warren. Major prizes include: Ten-Tec Omni C with power supply; Ten-Tec Delta: Icom 2ATs. Tickets $2.50 advance; $3.00 gate. Banquet Saturday evening, August 15, tickets $10.00. For information and tickets: Warren Hamfest, PO Box 809, Warren, Ohio 44482.

OREGON: The Willamelta Valley DX Club's 1981 Northwest DX Convention, August 8 and 9, Greenwood Inn, Beaverton, just west of Portland. Speakers, WA4ZNH/WB4FVU. Grand prize: ICOM-730. For information: Willamette Valley DX Club, PO Box 555, Portland, OR 97207.

RHODE ISLAND: The Bristol County Amateur Radio Association's annual indoor/outdoor flea market, Sunday, September 13, V.F.W. Hall, Tiverton. 12 noon til 4 PM. Flea market spaces, $6.50. Admission: $1.00. Talk-in on 147.63/03 and .52 direct. Door prizes. For info and maps: SASE to Ann M. Carro, KA1DNB, 652 Old Colony Terrace, Tiverton, RI 02878.

SOUTH DAKOTA: The 15th annul CSVHF Society Conference, July 30, 31 and August 1, Holiday Inn-Airport, Sioux Falls. Fun and activities for the entire family. For details: W0SD.

VIRGINIA: ARRL Roanoke Division Convention September 26 and 27 in the Virginia Beach, Virginia Pavillion. Free transportation to the oceanfront where the Neptune Festival is also taking place. FCC Amateur Exams given to those sending form 610 request in advance. Admission $3.50. Advance ticket drawing for FM transceiver. Flea market tables, $5 day, $7 both days. TRC PO Box 7101, Portsmouth, Virginia 23707. 804-587-1695.

WEST VIRGINIA: The East River Amateur Radio Club's Hamfest '81 on Sunday, August 23, Bluefield, Armory-Civic Center, one mile north of Bluefield on US 52. Admission: $2.00 advance, $3.00 gate, includes prize ticket. Tables $5.00 ($4.00 each for 3 or more). Tailgaters $2.00. Food, dealers, flea market, forums, entertainment — something for the whole family. Talk-in 89/49, 52/52. For info: Bluefield Hamfest '81, 2113 Hemlock Hill, Bluefield, WV 24701.

QUEBEC: RAQI, Radio Amateur du Quebec's annual convention, August 1 and 2, CEGEP Levis-Lauzon, 205 mgr Bourget, Lauzon, near Quebec City. Inquiries to Jean-Marc Labarre, VE2BZL.

OPERATING EVENTS
"Things to do..."

JULY 27 - AUGUST 4: Amateur Radio Station K2BSA will operate from the 1981 Boy Scout Jamboree at Fort A.P. Hill. Operation will be on 80-10 meters. See August QST for frequencies. No formal schedule. Best bet evenings. QSL card and SASE to K2BSA/4, c/o ARRL HQ, 225 Main St., Newington, CT 06111.

AUGUST 1 & 2: Micro-expedition to Forest County, Pennsylvania. Call WB3IQE/3. Mode: CW only. Frequencies: 80, 40 and 15 meters. Will operate in bottom 50 kHz of each of two bands, exact frequencies depending on conditions. Time will be spent outside the extra-only subbands. QSL to WB3IQE, Rt. 1, 3 ox 297, Brockway, PA 15824. US/Canadian stations, send SASE. DX stations, 1 IRC for QSL via ship, 2 IRCs for QSL via air.

AUGUST 15: The Englewood Amateur Radio Association's 22nd annual New Jersey QSO party. Time: 2000 UTC Saturday, August 15 to 0700 UTC Sunday, August 16; 1300 UTC Sunday, August 16 to 0200 UTC Monday, August 17. Phone and CW are considered same contest. General call "CQ NEW JERSEY" or "CQ NJ." Suggested frequencies: 1810, 3535, 3900, 7035, 7135, 7235, 14035, 14280, 21100, 21355, 28100, 28610, 50-50.5 and 144-146. Phono activity on even hours; 15 meters on odd hours

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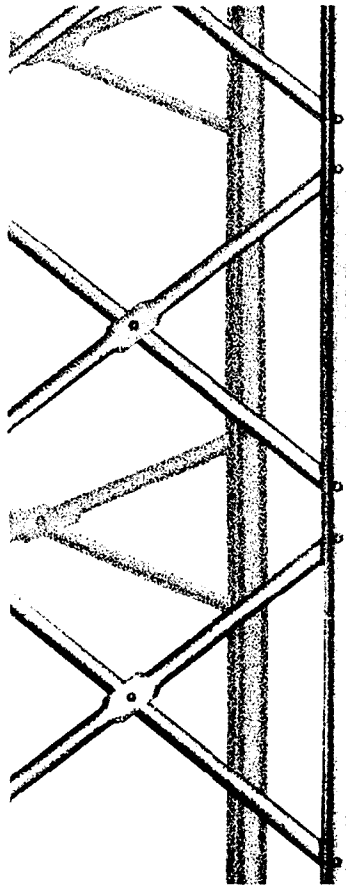
AUGUST 22: TMI FUN DXpedition: The Central Pennsylvania DX Club will hold the world's first DXpedition to Three Mile Island, the site of the Nuclear Power Facility made famous in news recently, from 1200Z Saturday August 22 until 2100Z, Sunday, August 23. Tentative frequencies: Phone - 3900, 7240, 14260, 14290, 21325, 21375, 28625 and 146.58. CW - 21125 and 7125. For an attractive photo QSL card for contacts, send SASE or IRCs to: CPDXC, c/o WB3DNA, T. Fanus, 6140 Chambers Hill Road, Harrisburg, PA 17111.

AUGUST 27: The Pend Oreille Amateur Radio Club's "Special Event Station" will be operating August 27, 28, 29 and 30 from 1600Z to 0500Z each day during the Pend Oreille County Fair at Cusick, Washington, using the Newport High School's ARC call WB7TBN. Frequencies: 14.340, 21.400, 28.700, 39.45, 37.15 CW. RTTY 28.090, 21.090, 14.080, 36.50. For a special commemorative QSL card SASE to: Mike Bice, WB7SGU, Star Rt., Box 251, Spirit Lake, Idaho 83869.

SEPTEMBER 9: "CQ YL" Howdy Days. Wednesday, September 9 at 1800 UTC through Friday, September 11 at 1800 UTC. All bands and modes of emission may be used. YLRL member or non-YLRL member. All licensed women operators world-wide are invited to participate. For information: Kay Eyman, WA@WOF, RR2, Garnett, Kansas 66032.

SEPTEMBER 12: "FIRE MUSTER," a special events station N@ARU@, will be on the air September 12 from 1400-2200 UTC, commemorating Burnsville, Minnesota's third annual Fire Muster. Amateur Radio in Public Service is this year's theme. Operating frequencies: 7.260, 14.285, 21.285, 28.550 MHz ± 5 kHz. Local 2 meter contacts will be on 16/76. For a commemorative QSL certificate SASE to: N@ARU, c/o David L. Justis, 14129 Frontier Lane, Burnsville, MN 55337 or via the ARRL DX Bureau.

SEPTEMBER 12 & 13: The Albuquerque, New Mexico, DX Association will sponsor a QSO party. Suggested frequencies: CW - 63 kHz from the low end of each band. SSB - 3900, 7265, 14285, 21365, and 28650 kHz. Novice — 3705, 7105, 21105, 28105 kHz. Entries must be postmarked no later than October 15, 1981. SASE to Albuquerque DX Association, PO Box 997, Corrales, NM 87048 for complete results.



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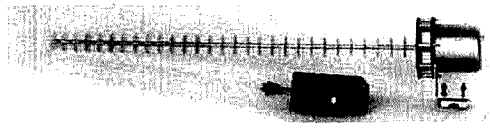
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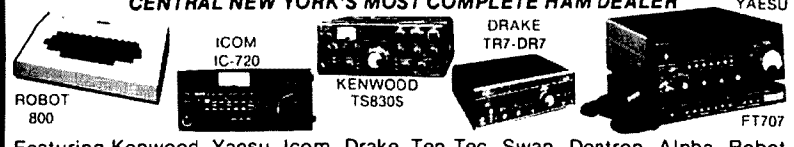
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More Details? CHECK—OFF Page 94

HAM CALENDAR

August

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						CENTRAL STATES VHF SOCIETY'S 15TH ANNUAL CONFERENCE – Holiday Inn Airport, Sioux Falls, SD – W0SO 1. **ILLINOIS QSO PARTY** 1-2. **MICRO-EXPEDITION** to Forest County, PA. Call WB3IQE/3. Mode CW only. Frequencies 30, 40, and 15 meters – WB3IQE 1-2. **33RD ANNUAL UPPER PENISULA HAMFEST (MICHIGAN)** – Delta County Repeater Assoc., Flat Rock Township Hall, Escanaba, MI – WA8DHB 1-2. **JACKSONVILLE HAMFEST & NORTHERN FLORIDA ARRL CONVENTION** – Orange Park Kennel Club, I-295 & U.S. 17 south of Jacksonville 1-2. **RADIO AMATEUR DE QUEBEC** – Annual convention at CEGEP Levis-Lauzon, 205 Mgr. Bourget, Lauzon near Quebec City. Call VE2BZL 418-871-2850 1-2. **1**
23RD ANNUAL CROOKED LAKE FM PICNIC & HAMFEST – by Steuben County Radio Amateurs, Angola, IN – WB9YIT 2. **NORTHWEST KANSAS 1ST AMATEUR RADIO SWAP MEET** – Community Bldg, Colby, KS – WA8GBN or KA8FBQ 2. **ILLINOIS BELVIDERE BIG THUNDER ARC ANNUAL HAMFEST** – Boone County Fairgrounds, Hwy 76 – K9DGG 2. **3RD ANNUAL NORTH CENTRAL MISSOURI HAMFEST** Municipal Auditorium, Moberly, MO – WB9ENV 2. **2**	**WEST COAST BULLETIN** 8 PM PST (0400 UTC) 3540 kHz, A-1 22 WPM 3. **3**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **4**	**5**	**WEST COAST QUALIFYING RUN** 6. **6**	**7**	**EUROPEAN C.W. CONTEST** 8-9.* **UHF CONTEST** – Begins 1900 UTC Sat. and ends at 1900 UTC on Sun. 8-9. **NORTHWEST QX CONVENTION** – by Willamette Valley DX Club, The Greenwood Inn, Beaverton, OR. Write POB 555, Portland, OR 97207. 8-9. **BURLINGTON ARC ANNUAL INTERNATIONAL HAMFEST** – Old Lantern Campground, off route 7, Charlotte, VT – W1VSA 8-9. **TRI-COUNTY AMATEUR RADIO ASSN. ANNUAL HAMFEST** – Los Angeles County Fairgrounds, Thummer's Patio. Write TCARA, POB 142, Pomona, CA 91767. 8. **8**
ST. CLOUD AMATEUR RADIO CLUB HAMFEST – Whitney Sr. Center, St. Cloud, MN. Contact Mike Lynch, KA0HQS 9. **CENTRAL KENTUCKY ARRL HAMFEST** – by the Bluegrass Amateur Radio Society at Tates Creek Jr. H.S., Centre Parkway, Lexington, KY – K4DHN 9. **HAMFESTERS RADIO CLUB'S 47TH ANNUAL HAMFEST** Santa Fe Park, 91st & Wolf Rd., Willow Springs, IL N9BIA 9. **9**	**10**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **11**	**12**	**W1AW QUALIFYING RUN** 13. **13**	**TEXAS VHF FM SOCIETY STATE CONVENTION & 2ND ANNUAL SUPER CENTRAL TEXAS SWAPFEST** – Hilton Inn, Austin, TX. Contact VHF '81, POB 13473, Capital Sta., Austin, TX 78711 14-16. **14**	**ALL ASIAN CW CONTEST** 22-23*. **RHODE ISLAND QSO PARTY** 15-17. **RADIO CLUB OF TACOMA ANNUAL HAMFAIR** – Pacific Lutheran University, Tacoma, WA – WB7ONS 15-16. **NEW JERSEY QSO PARTY** 15-17. **15**
SIXTH ANNUAL NEW DELMARVA HAMFEST – Glorylend Park, Boar, DE. Contact K3HBP, 14 Balsam Rd., Wilmington, DE 19804 16. **10TH ANNUAL LAFAYETTE HAMFEST** – Tippecanoe County Fairgrounds in Lafayette, IN 16. **16**	**WEST COAST BULLETIN** – 8 PM PST (0400 UTC) 3540 kHz, A-1 22WPM 17. **17**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **18**	**19**	**20**	**21**	**OHIO QSO PARTY** – 22-23. **TMI FUN DXEDITION** – Central PA DX Club's first DXpedition to Three Mile Island. QSL to CPDXC, c/o WB3DNA 22-23. **22**
W1AW QUALIFYING RUN 23. **ST CHARLES ARC HAMFEST** – Wentzville Missouri Community Club. Contact SCARC Hamfest 81, c/o Bill Graham, 512 Bermuda Dr., O'Fallon, MO 63366 23. **BLUEFIELD HAMFEST 81** — by East River ARC at Bluefield Army Civic Center, 1 mi north of Bluefield, WV on US 52. Write Bluefield Hamfest, 2113 Hemlock Hill, Bluefield, WV 24701 23. **1981 ILLINOIS STATE ARRL CONVENTION** – by Fox River Radio League, Kane County Fairgrounds in St. Charles, IL 23. **IOWA 75 METER NET PICNIC & SWAPFEST** – Ewing park in southeast Des Moines, IA. Contact WB0JFF 23. **23**	**24**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **25**	**26**	**PEND OREILLE ARC "SPECIAL EVENT STATION"** – from Pend Oreille County Fairgrounds at Cusick, WA, on 1600Z to 0500Z using call W87TBN 27-30. **27**	**28**	**29**
SHAWNEE AMATEUR RADIO ASSOC. 25TH ANNUAL HAMFEST – At John A. Logan College west of Carterville, IL on State Rt. 13. 30. **GLOUCESTER COUNTRY ARC HAMFEST** – at Gloucester Country College, Tanyard, Rd., Sewell, NJ. Contact Hamfest Committee, POB 370, Pitman, NJ 08071 30. **LAPORTE COUNTY HAMFEST** – County Fairgrounds on Hwy 2 west of LaPorte, IN 30. **30**	**31**					**W1AW Schedule** **April 26-October 28, 1981** UTC Slow Code Practice: MWF: 0200, 1300, 2300; TThSSn: 2000; S: 0200 Fast Code Practice: MWF: 2000; TTh: 0200, 1300; TThSSn: 2300; S: 0200 CW Bulletins: Dy: 0000, 0300, 2100; MTWThF: 1400 Code practice and CW bulletin frequencies: 1.835, 3.58, 7.08, 14.08, 21.08, 28.08, 50.08, 147.555 MHz.

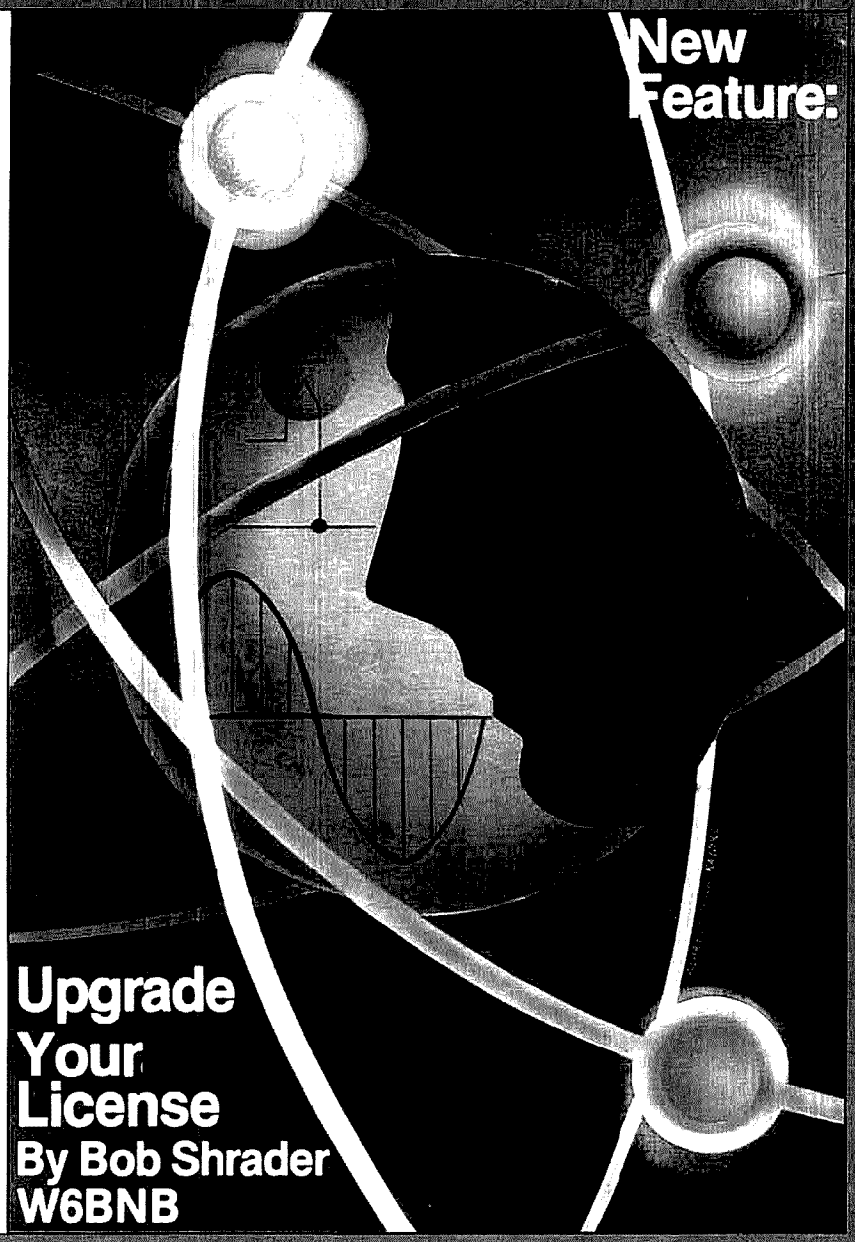
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- the half-wave vertical 36
- digital techniques 43



New Feature:

Upgrade Your License

By Bob Shrader W6BNB

hr

focus on communications technology

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SEPTEMBER 1981

volume 14, number 9

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by Skip Tenney

We asked for it and we sure got it. We've received a huge response to our survey in the May issue. It was designed to find out just who you our readers are, what your Amateur Radio interests are, what you think of the job we're doing, and what changes if any you would like to see in the magazine as we continue to work to fine tune the combined *ham radio*/HORIZONS that we put together earlier this year.

The number of returns and the amount of information we've collected are virtually overwhelming. Not only did we get a tremendous response to the questionnaire itself, but we also received a large number of thoughtful and very helpful letters from readers who felt that the necessarily limited questions we had asked did not give them enough of an opportunity to properly express themselves. We have already put many days of effort into trying to reduce this information into a useful and meaningful form. It isn't enough just to come up with the raw percentages of answers given to each question. We are putting a good deal of effort into cross-tabulating this data in order that we may learn just why those who like what we're doing feel that way, and why those who think we're going astray hold their opinion.

Many of the answers came out much as we had expected. Former HORIZONS readers missed their old magazine, but were increasingly satisfied with the changes we have been making, while some former *ham radio* readers lamented the changes to their favorite magazine. At the same time many offered constructive ideas as to what they would like to see in the magazine. Perhaps the most exasperating part has been the several features which seem to show up at both extremes of reader opinion. One group of readers will list a feature as most disliked while a similar sized group think the same item is the best part of the magazine.

It was very interesting to find out just who our typical readers are. For instance, we learned that engineers and technically employed people were the largest single active job category among former HORIZONS readers. We expected this from *ham radio* readers, but it came as quite a surprise to find out that 45 percent of *all* our readers are in that category.

By now you are probably wondering just how our report card came out. Have we been doing a good job or haven't we since combining our two magazines into one publication? Well 56 percent said that they like us as much or even better than before, while 44 percent preferred our previous approach, when we were publishing two separate magazines. And even among those who preferred our previous approach, very nearly half listed the new *ham radio* as their favorite Amateur Radio publication. These figures represent a great number of loyal readers.

Although not as high as we might like, these numbers do offer us very real encouragement. We're looking very carefully at the group who feel the new magazine is not as much to their liking as before and we'll be trying to offer a bit more to them while at the same time continuing to appeal to those who say we're doing just fine now.

Although we are far from having completely digested all of what you've told us, we are going to begin responding to your stated preferences by running a number of articles which will be a bit more in the traditional *ham radio* mold — although whenever possible we will try to edit them so that the reader who is technically less sophisticated can also learn a lot from them. Every reasonable effort shall be made to maintain *ham radio*'s pre-eminent technical reputation, while at the same time we maintain the greater balance we feel we've given to *ham radio* in recent months.

While we're on the subject of new features, it is with a great deal of pleasure that we direct your attention to a new series of license-upgrading articles by Robert L. Shrader, W6BNB, which starts in this issue. He is the author of the extremely popular license text *Electronic Communication*, which is by far the most thorough study guide in print for all FCC exams, both Commercial and Amateur. Bob's very complete yet easy to understand way of presenting material has led to many, many successful exam papers. His new series here in *ham radio* will add to that reputation I am sure. In fact, even many of you who are not in the process of upgrading will find this review of the technical basics valuable. Even our staff has been learning from Bob.

We've still got quite a way to go in evaluating and learning from the data you've given us (in fact we're still receiving over 25 replies each week), but when it's all over I think all of us, readers and editors, will find this time taken to reflect on where we stand and where we are going to have been very well spent. I'd personally like to thank all of you who have helped make this survey so successful. We have what we feel is the best magazine in Amateur Radio and we want to do everything we can to strengthen and further solidify that position.

Skip Tenney, W1NLB



comments

on-air tune-up

Dear HR:

I enjoy Bob Locher's DX stories, but he certainly does not set a good example for the young aspiring DXer. Bob says, " 'OK Jerry, I hear him. Thanks a lot.' I move my VFO a couple of kHz above him and start tuning. The linear plate current, grid current, and rf output start climbing as I advance the exciter drive control."

Well, his rig blew — as should all who tune up in the band. No, I really don't mean that. But I guess Bob has never heard of a dummy load! Hey! The bands are full of creeps who tune their rigs on the bands. I for one am persistently plagued by tuner-uppers on stations I am working, and it seems invariably it's the really weak ones too!

When it comes right down to it, a dummy load is so darned easy to switch in for tune-up that it really is ridiculous not to use one. They are cheap too!

Fred Streib, W6NA
Palo Alto, California

Yes, I do tune up on the band, as does virtually everyone else. I have a dummy load, an excellent one, and I can switch it on line in a second or so. And, on the frequencies I operate on, it is virtually dead flat.

But my antennas are not! They display good SWR readings on the frequencies I normally operate on, but they are not perfect. Not only that, but they change a bit depending on the weather conditions. Wind or rain will change their characteristics slightly.

So, if I load up into my dummy load, I still have to retune once I am into a real antenna, or face poor harmonic rejection from a mistuned final, not to mention stress on the finals.

I do have preset tuning points marked on all my gear, and almost invariably I can complete a tune-up in less than five seconds of key-down time on the air. And I always *check the frequency before I do to insure that I cause no intereference.*

"No tune up" would be really nice, but in the real world using the equipment most Amateurs use it is impossible, even with solid-state finals which often require an antenna tuner with them. But, as Mr. Streib suggests, we have an obligation to avoid QRMing another QSO.

Bob Locher, W9KNI
Deerfield, Illinois

baluns

Dear HR:

I read with interest the fine article entitled "A Coreless Balun" by Roy N. Lehner, WA2SON, in the May, 1981, issue of *ham radio* magazine.

The first reference to this interesting device was in the Collins Radio Company's "Single Sideband Manual" (1965). Unfortunately, no construction data was given. I built several coaxial baluns and made measurements on them; in the February, 1966, issue of *CQ* magazine I gave several practical designs in an article entitled "A Broadband Balun for a Buck."

A replica of this design has appeared in each edition of the *Radio Handbook* for 14 years. Additional information on similar balun designs is included in the 21st edition of the handbook, which is published by Howard W. Sams Co., and available through Ham Radio's Bookstore.

Also discussed in the *Radio Handbook* are the small, air-core baluns wound of Formvar or enameled wire. Roy, WA2SON, claims the coaxial design is "much better" than the enameled wire balun, but this is like comparing apples and oranges. Each balun design has attributes that the other does not possess.

The enamel wire, air-wound balun is more compact than the coaxial design, weighs less and is not subject to coaxial cable "cold flow," wherein the center conductor migrates about and may short out to the shield — especially when the cable is wound into a small-diameter coil. And when properly designed, the enamel-wire balun has a somewhat greater frequency range of operation than the coaxial balun; that is, it is more "transparent" to the antenna system, as far as induced SWR goes, than is the coaxial design.

The coaxial cable balun, on the other hand, can probably withstand more brute power than the wire balun because of the higher breakdown voltage of the cable. Over the normal operating range, at normal ham power levels, there isn't much choice between the designs except on the basis of size or weight.

So you pays yer money and takes yer choice. But don't write off one particular balun design as being worse than another one. It isn't.

William I. Orr, W6SAI
San Carlos, California

nit-picker

Dear HR:

In the May, 1981, edition you have an article by John W. Frank, WB9TQG. This is a very interesting concept and will be of some help to the Amateur community. I wish I had thought of it.

But being the nit-picker that I am, I couldn't help but notice two errors. The first is the use of the symbol K **(eq. 2)**. This is usually used to designate a constant, not a reflection coefficient, which is designated by the symbol ρ. In the interest of clarity, the correct symbol should be used.

Second is the assertion that SWR will increase line losses. To examine this point let's look at a line of unit length with a 3 dB loss per unit length. With a generator and load matched to this line we find that when 100 watts is delivered into this line only 50 watts is delivered to the

load, the remaining 50 watts being "lost" in the line. This confirms the 3-dB loss factor. Now then, if we mismatch the load such that it is infinite (or as near as we can get to ∞) we can make another measurement and find that the SWR is very high and 25 watts now show up on our (directionally coupled) wattmeter at the generator end of the line. This tells us that at the far end we have lost an additional 25 watts (that is, 3 dB for the return trip).

This is the argument presented in the article, and you can see that the line loss factor has remained at 3 dB per unit length; it has not changed. We can infer from this that the line loss is constant and does not change with SWR. Any loss in addition to this in the load is the result of impedance mismatch (although it will be reflected to the generator as reactance, detuning the output network and probably aggravating the "loss" situation by further complication).

We may look at this as if the "reflected power" is absorbed by the PA plate circuit and dissipated there as heat, which is what the FCC says, and we won't be too far off base.

Michael D. Smith, WD4KMP

Just between us nit-pickers, I must admit that you are right. However, reference 2 used the letter K. The Radio Handbook, *21st edition, presents a different form of my* ***eq. 2*** *on page 25.8 and the reflection coefficient is again represented by the letter K.*

Regarding the increase in total line loss due to standing waves: According to the ARRL Electronics Data Book, *copyright 1976, page 82, "An increase in line loss occurs because of SWR." A graph showing additional loss caused by SWR is on page 83 of this data book. This same information is presented in nomograph form in* Reference Data for Radio Engineers, *6th edition, page 24-10.*

Proving the existence of the additional line loss takes about 26 pages of higher mathematics; I made the assumption that it is common knowledge.

John W. Frank, WB9TQG

at a loss

Dear HR:

I can't believe it, that what's given in fig. 1 ("Measuring Coax Cable Loss," May, 1981, page 34) is really SWR. How about:

$$SWR = \frac{1+\frac{|R-Z|}{|R+Z|}}{1-\frac{|R-Z|}{|R+Z|}}$$

Since when is the reflection coefficient equal to the reflected power/forward power — which the meters don't read anyway?

If the line is (presumably) an open circuit it will be difficult to deliver 100 watts to it — unless it's *very* lossy.

I suggest you see the February, 1981, issue of *QST*, page 26. It can be done this way:

$$P_1(FWD) - P_1(REFL) - P_2(FWD) = loss$$

J.T. Kroenert, KA1PL
Barrington, Rhode Island

Yes, Mr. Kroenert, that is SWR. If you check reference 1 (listed at the end of my article) you will find that $SWR = R/Z$. *If you prefer the equation you refer to in your letter, let* R *equal infinity and* Z *equal 50 ohms, and the SWR will still be infinite.*

If you read my article carefully, you will note that I never said the reflection coefficient equals reflected power/forward power. What I said was, "...since SWR is a function of forward and reflected power...." I did not say it was a ratio; I said it was a function.

Your suggestion that loss can be measured by noting the difference between wattmeter readings at the source and at the load will work. However it isn't as convenient as my method. For example, if I chose to use your method, I would have to climb my tower and disconnect the coax from the antenna. Then, with my dummy load up 60 feet in the air, I would return to the shack to make power measurements. Next, I would have to invite another Amateur over to the shack. Why do I need another Amateur? I need someone to key the transmitter while I'm at the top of the tower making more power measurements. I said, your method will work but mine is more convenient.

John W. Frank, WB9TQG

blow your own horn

Dear HR:

After reading the Comments in *ham radio* (May, 1981), one might get the impression that experts don't want too much to do with anyone who might be coming up the ladder or maybe received his license without a complete knowledge of electronics.

Many permits and licenses are issued today with little or no knowledge — namely marriage, hunting, and driver's — at least with a ham license you won't kill anyone.

I am a professional driver and have driven tractor trailers, buses, motor homes, and cars the equivalent of eighty times around the world, but this does not mean that a novice driver with two hours of instruction and practice can't take a 400-horsepower car on the interstate and do battle with the experts.

So all you super pros in Amateur Radio (who I trust are in the minority) keep blowing your own horns and someday when we meet on the road, I'll blow mine.

Fish Gilpin, KA3DNT
Greentown, Pennsylvania

presstop

SATELLITE-RELAYED AMATEUR RADIO PACKET communications became a reality in Canada in July when packets were exchanged over the ANIK-B research satellite. The pioneering contact was made by VE3FOL in Ottawa and VE7APU in Vancouver, operating from the satellite ground stations at 1200 bits/second.

The Satellite Channels have been made available to Amateurs on a "space available" basis, under an authorization granted by the Department of Communications. Tie-ins with local "computer bulletin boards" and other computer hobbyist activities are also planned, so eventually not only Amateurs but non-Amateurs will be using the Amateur-built system.

STRONG ORGANIZED SUPPORT FOR AMATEUR RADIO is being proposed by a newly formed group in California, the Society for the Protection of Amateur Radio (SPAR). SPAR, the brainchild of K6QYO and W6POU (Santa Barbara County SCM), states as its purpose "to support when needed the interests of Amateur Radio as defined by the ARRL, with the strongest possible political action against harmful regulation and legislation, and to support that regulation and legislation which is beneficial." The SPAR articles of incorporation, which were signed June 14, are highly supportive of the ARRL but very critical of the FCC...in particular, the plain language rewrite.

SPAR Says It Will Support Amateur Radio through organized letter writing campaigns, introducing legislation and legal actions, and eventually by putting a "full-time legislative advocate" in Washington. The organization plans to work with and through the League, but feels it would be in a position to accomplish things that the ARRL cannot. Thus far it has received strong support from ARRL Southwestern Division Director W6EJJ, who plans to keep League officials aware of its progress. SPAR was discussed at the June executive committee meeting, but no position on it was taken.

SPAR's Support So Far is mostly from southern California, where it seems to be catching on rapidly. Interested Amateurs can write (SASE) SPAR, Box 41, Santa Barbara, California 93108 or call (805) 969-5304, 969-5623, or 642-7141.

SPREAD SPECTRUM HAS BEEN PROPOSED for the Amateur service in a Notice of Inquiry and Proposed Rulemaking announced by the FCC July 1. In this action the Commission proposes limiting use of the sophisticated broadband technique to the 6, 2, and 1¼ meter bands, by Advanced and Extra class licensees only. Though some technical details are proposed in the item, the principal limitation is that emissions be contained within the given band.

Further Details are not yet available. However, the document will pose a number of questions on such topics as how Amateur spread spectrum transmissions could be monitored and what potential interference would result from them. The complete text of FCC 81-290 should be in the Federal Register and available from the usual FCC sources.

Spread Spectrum Radiolocation in the 420-450 MHz band has also been proposed in a related action, FCC 81-291. Responding to a petition by Del Norte Technology, this FCC NPRM would let Del Norte use radiolocation equipment, previously limited to off-shore areas, within the United States. Such use would, however, be on a non-interference basis with government and Amateur use of the band.

Comment Dates On These Items have not yet been announced, but a long comment period, at least on the Amateur item, is expected.

Spread Spectrum Operation on the lower-frequency Amateur bands has already taken place under an FCC Special Temporary Authority. A detailed report on these first Amateur experiments, by AMRAD members W4RI, K2SZE, and WA3ZXW using commerical spread spectrum rigs on 75 meters, appears in the July AMRAD Newsletter. Amateurs interested in following the progress of this mode, as well as packet radio and application of computer technology to Amateur Radio, should join AMRAD. Membership is $12 a year, to treasurer N4GA.

ANTENNA PROBLEMS HAVE BROUGHT another Amateur to the Courtroom. N5SW of Kryder Electronics is suing Oklahoma City, after the city building inspector informed him his 78-foot tower was in violation of the city's 50-foot tower ordinance, and the city Variance Board denied him a variance for it.

The Suit, Which Was Filed June 11, has received much media attention in Oklahoma City and was picked up by UPI. In it, N5SW asserts the 50-foot restriction "limits my freedom of speech and violates my civil right to control my own property." In addition, he maintains the tower "is a necessary requirement in the exercise of my avocation" and the ordinance "limits the exercise of my federally granted Amateur Radio privileges."

N5SW Was Arrested in his home eight days after the suit was filed in Federal District Court and charged with violating the 50-foot ordinance. Contributions are being solicited to assist in the action by the Oklahoma City Antenna Defense Fund, c/o ADIS, Box 32735, Oklahoma City, Oklahoma 73123.

ARRL Is Watching N5SW's case closely, along with a half dozen others that were reviewed at the June 20 Executive Committee meeting. The League, under its tax exempt status, cannot assist an individual member financially in such a case unless its participation would benefit all its members. The League can assist only if the case is precedent setting, or would upset a previous precedent.

upgrade your license:
part 1

The first article in a continuing series designed to help you upgrade your ticket

If you are **reading** this magazine, you probably already hold an Amateur Radio Service license of some grade. Maybe you are a Novice. More likely you are a Technician, General, or better. A good theory review now and then is a good idea for all of us, Extras included.
frequencies and types of emission — right? Does it bother you that someone else can use them but you can't? Well, it was a challenge for all of those Extra-class hams who are using those frequencies, but they did something about it: they upgraded.

Bob's next article on license basics will explain items such as inductive and capacitive *reactance*, *impedance*, phase angles, solving simple ac circuits, reactive power, power factor, simple series and parallel circuits, impedance matching, series and parallel resonance, circuit *Q*, basic filters, wave traps, and a simple black-box circuit.

This means that not only did they learn more radio theory but they also improved their code sending and receiving abilities, which enables them to function better in an emergency where phone equipment is either not working or unavailable. Maybe they found out that code communications is a heck of a lot of fun when you get to the point where you can sit back and copy in your head, and not bother to write everything down on paper. Really, that transcribing the code is for the birds! We will talk about this later, but right now be sure that each day you have at least one good QSO on the air using CW, to raise yourself above that crawling along at 5 or 13 words per minute (WPM).

Probably the largest group of readers interested in upgrading are in the Technician/General category. For this reason, we will first concentrate on upgrading this group to the Advanced class license. Later we will take on the Extra class — so keep working on that 20 WPM code speed goal. If you are a Novice (or not yet a Novice), you will find that the fundamentals we are going to work on first should enable you to work up to the Technician/General level. At the beginning of each article we will point out what FCC topics are to be discussed in that article. In this month's article, the first in the series, you will find

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basic electrical topics suitable for Novice, Technician/General, and Advanced license questions.

The first few articles will lay out the groundwork, so that we will all be speaking the same electronic language. If we say such things as current, resistance, reactance, or impedance, it should mean the same to all of us. Once we all understand the basic language we can better discuss the more advanced subjects.

The study of Amateur Radio theory requires some knowledge of electricity (volts, ohms, amperes, resistors, magnetism, coils, capacitors), electronics (diodes, transistors, vacuum tubes), basic circuits (oscillators, amplifiers), combinations of circuits which we will call systems (receivers, transmitters), antennas, FCC rules and regulations, radio telegraph code, and proper on-the-air operating procedures.

The FCC is basing its present license tests on nine areas of information:

a. Rules and Regulations
b. Operating Procedures
c. Radio Wave Propagation
d. Amateur Radio Practice
e. Electrical Principles
f. Circuit Components
g. Practical Circuits
h. Signals and Emissions
i. Antennas and Feedlines

FCC test topics

The following Novice test topics are discussed in this article, but should be understood by Technician/General and Advanced applicants also:

- *ampere*
- *voltage*
- *volt*
- *conductors and insulators*
- *watt*
- *energy and power*
- *fuses: appearance, applications, symbol*
- *open and short circuits*
- *direct current*
- *alternating current*
- *metric prefixes: mega, kilo, centi, milli, micro, pico*
- *hertz*
- *audio frequency*
- *radio frequency*

The following Technician/General test topics are discussed in this article, but should be understood by Advanced applicants also:

- *resistance*
- *resistors: appearance, types, characteristics, applications, symbols*
- *resistors in series*
- *ohm*
- *Ohm's law*
- *power calculations*
- *power measurement*
- *electrical power calculations*
- *root-mean-square value of a sine-wave alternating current*
- *inductance*
- *inductors: appearance, types, characteristics, applications and symbols*
- *henry, millihenry, microhenry*
- *capacitance*
- *capacitors: appearance, types, characteristics, applications, and symbols*

The following Advanced class test topics are discussed in this article:

- *sine, square, sawtooth waveforms*
- *root-mean-square value*
- *fields, energy storage, electrostatic, electromagnetic*

For additional information on these subjects you might refer to Electronic Communication, *by Robert L. Shrader, McGraw-Hill Book Co., both a commercial and Amateur license text, available through Ham Radio's Bookstore, Greenville, New Hampshire 03048 ($26.95 plus $1.00 shipping).*

Under these categories the FCC lists many specific topics. They do not indicate the questions they will ask, only what subjects the questions will cover.

All of the Amateur license tests contain one or more questions on all of the specified areas. For the Novice exam the level of knowledge required is rather rudimentary. For the Technician/General exam you'll need a good basic understanding of radio. For the Advanced class license the qualifications are definitely higher, and some of the questions seem to come from out in left field somewhere. As for the Extra-class license, well, you are supposed to know a lot about a lot of things. A word of warning is advisable here. Although they do not say so, the FCC tends to reach back down to lower level license topics for some of their test questions. You might find some Technician/General questions on Advanced license tests. But if you have passed the lower license you should not have too much trouble.

This series of articles will try to cover the whole field for you. We are sure that many hams who have had a license for several years have managed to forget most of the theory that they learned previously. So, to refresh their memories and to help those of you who do not have at least a Technician/General license, we will first go over the basic Electrical Principles and the Circuit Components, as taken from the FCC list above. Other categories of information will be covered in later articles.

There is no way that we can guess what the FCC is going to ask you on their present or on future tests. But if you have a good, basic understanding of the topics in the FCC list, you stand a good chance of choosing the correct answer in their multiple-choice test questions. Happily, you can miss a few and still get your license. After all, a 75 percent grade on a test gives you just as valid a license as a 100 percent score would. You might feel better if you made the 100 percent grade, but how many of us are perfect?

The idea of this series is to put radio theory into words you can understand, even if you have little or no training in this field. We are not out to produce electrical engineers, just knowledgeable Amateur Radio operators. If you want more information than you find here, there are textbooks that you can read once you understand the basic ideas.

One thing more. You must have a copy of Part 97, FCC Rules and Regulations, obtainable from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.* Space here is too limited to permit us to repeat all of the information on rules and regulations. Let's get started.

*Also published in *The Radio Amateur's License Manual*, available from Ham Radio's Bookstore, Greenville, NH 03048 ($4.00 plus $1.00 shipping).

electrical current

Every electrical or radio device operates because a current of "things" moves through the copper wires and the device. The "things" that move are called electrons. We probably all know that everything that can be seen or felt is made up of atoms, usually in chemical combination with other atoms to form molecules. An atom consists of a central nucleus, which is made up of relatively heavy, zero-charged particles called neutrons and positively charged particles called protons. Essentially, the nucleus of an atom is never altered. Nothing we can do, short of nuclear fission or fusion, will alter it.

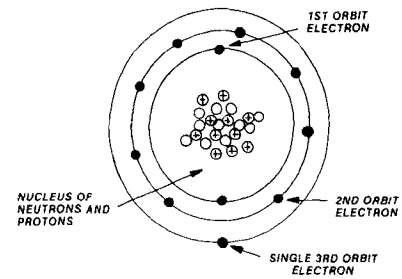


fig. 1. Representation of an atom that would make a good conductor.

Surrounding the nucleus, however, are orbiting electrons, **fig. 1**. The electrons have a negative charge and are attracted to the positive charges of the nuclear protons. These constantly moving electrons *travel in orbits* around the nucleus, somewhat similarly to the way in which the planets orbit the sun. The earth is attracted to the sun by gravitational forces; electrons are attracted to the nuclear protons by electrostatic (negative to positive) forces.

The outermost electrons of some atoms are susceptible to external effects. For example, if a single, outer-orbit electron is brought near a higher positive charge it may be stolen from its parent atom. This leaves the atom minus one electron, and therefore with one excessive positive charge in its nucleus. We say the atom has been ionized by losing the electron, and is now a positive ion. (We may think of this as being an electron hole in the ionized atom.)

In our real world we have dry cells (called batteries if two or more are used together) that have the ability to chemically separate electrons from atoms and pile

the electrons on the negative terminal of the cell, leaving the opposite terminal electron-less, or positively charged. The chemicals can move only a given number of electrons across the cell before the electrical difference (electrostatic force) stops any further chemical action. In the common dry cell this occurs when an electrostatic force of 1.5 volts is across the cell. (Voltage is disussed in the next section.)

If we connect a flashlight lamp across the dry cell, using three pieces of copper wire and a switch, a simple electric circuit is formed, **fig. 2.** (Copper is used as connecting wire because it has one free, or easily moved, electron in its outermost orbit.) When the switch is closed, the excess electrons on the negative pole of the dry cell have a chance to move to the positive pole through the lamp and circuit. As a result, a current of electrons develops throughout the circuit. The copper wires allow the current to flow with almost no opposition, but the lamp's filament, made of tungsten or some other metallic wire, has fewer free electrons and tends to oppose the flow of the electron current. Because of this frictional opposition, energy is lost in the filament wire and it heats. Tungsten can be heated to a red, orange and even to a white-hot temperature without melting. Thus, while the copper connecting wires may heat slightly or not at all, the lamp filament heats white hot and light is radiated from it. When the switch is opened the current stops; the filament cools and it no longer radiates heat or light.

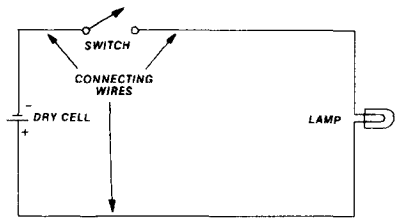


fig. 2. Simple lamp circuit.

In the dry cell, when electrons begin to enter the positive terminal, the electrical difference across the cell becomes less and the chemicals start working again, pumping more electrons to the negative pole from the positive. When the chemicals can no longer continue to move electrons across the cell, the cell is discharged, or dead. The cell converts chemical energy to electrical, and the lamp, or "load" on the circuit, converts the electrical energy to radiant (heat and light) energy.

An interesting sidelight to the subject of current is its direction of flow in a circuit. You can see that electrons must travel from the negative terminal of the source (the cell) through the outside circuit (the lamp or load), being attracted to the positive terminal. Back in the early days when electricity was first being investigated, cells were labeled positive and negative the same as today. It was only natural to assume that if something was traveling in the wires of electric circuits that it must travel from the terminal that had the most (positive) to the one that had the least (negative). So they said that current flowed from + to −, and they wrote all the textbooks that way.

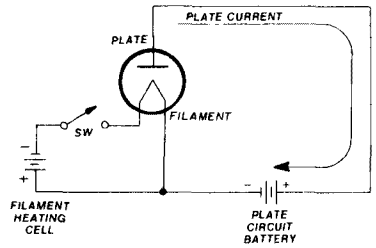


fig. 3. Adding a plate in a lamp produces a diode, or two-element control device.

In the early 1900s, when vacuum tubes were first being developed, it was found that hot filaments boiled free electrons off of their surfaces. A metal plate was put inside the vacuum area of a lamp; the plate could be made positive by connecting it to the positive terminal of a battery, provided the filament was connected to the negative terminal. A current could now flow through the plate circuit whenever the filament was hot, **fig. 3.** This proved that electric current actually flowed from the negative terminal of a source through the circuit to the positive terminal.

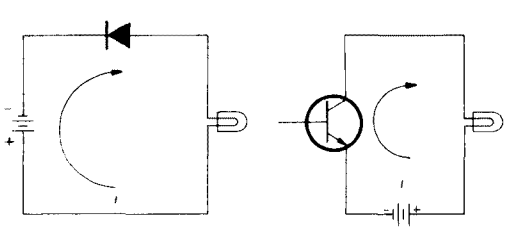


fig. 4. Electron current flows in the direction opposite to that indicated by the arrows on solid-state devices, which point in the direction of "conventional" current flow.

Well, that wasn't the way the textbooks said it was. Since nobody wanted to rock the boat, they just continued to teach that current flows from + to −, and the heck with the electrons! So, now we have two theories of current flow, one the original, "conventional" + to − theory, the other the electron theory. You will notice that all of the symbols on solid-state diodes, transistors, and so forth, **fig. 4**, have their arrows indicating current flowing in the conventional current direction. So, remember that symbols show conventional current direction, not the electron theory direction.

In **fig. 5** we have added a lamp as the load in the **fig. 2** circuit and substituted the correct symbol for a vacuum diode (two-element device). We have also added an ammeter in series with the lamp and the plate circuit B-battery. The ammeter measures the value of the current flowing through it, and therefore the current in the plate circuit. It is called an ammeter because *current is measured in amperes*, A. An ampere of current is considered to be 6.25×10^{18} electrons flowing past a point in a circuit in 1 second. Remember that 10^{18} means that you move the decimal place of the 6.25 over 18 places to the right (if the exponent were negative, 10^{-18}, you would move the decimal point 18 places to the left). That makes the number of electrons 6,250,000,000,000,000,000. From this you might deduce that an electron is a pretty small thing, and you would be right. A group of 6.25×10^{18} electrons is known as a coulomb (C), which is the basic unit of electric quantity (Q).

In modern radio we may more often measure current in thousandths of an ampere, called milliamperes, or mA. A microampere, or μA, is a millionth of an ampere. A billionth of an ampere is called a nanoampere, or nA.

The metric based prefixes used with electrical units of measurement are listed in **table 1**. You should know these.

table 1. Metric-based prefixes.

Pico (p, or $\mu\mu$)	= trillionth of	= 10^{-12} times
Nano (n, or mμ)	= billionth of	= 10^{-9} times
Micro (μ)	= millionth of	= 10^{-6} times
Milli (m)	= thousandth of	= 10^{-3} times
Centi (c)	= hundredth of	= 10^{-2} times
Deci (d)	= tenth of	= 10^{-1} times
No prefix	= unity	= $10^{0} = 1$
Deka (da)	= ten times	= 10 times
Hecto (h)	= hundred times	= 10^{2} times
Kilo (k)	= thousand times	= 10^{3} times
Mega (M)	= million times	= 10^{6} times
Giga (G, or kM)	= billion times	= 10^{9} times
Tera (T)	= trillion times	= 10^{12} times

voltage, resistance, and Ohm's law

The pressure exerted on electrons by chemical action in a dry cell has been explained as producing a moving force that makes electrons flow in a circuit. This pressure is known as electromotive force, or EMF, and is symbolized as E or e. Since it is measured in units called volts, it is also known as voltage, which is symbolized as V or v.

The opposition that the lamp filament had to the flow of electrons or current is properly known as resistance, symbolized as R. Resistance is measured in units called ohms, symbolized as Ω (the Greek letter omega).

One of the most important *formulas for* computing electrical circuit operation is Ohm's law, which simply states that if 1 volt of pressure is applied across 1 ohm of resistance, the resulting current value will be 1 ampere. Ohm's law is usually written as:

$$I = \frac{E}{R} \text{ and from this } E = IR \text{ and } R = \frac{E}{I}$$

where I = intensity of current in amperes (amps for short)
R = resistance in ohms
E = EMF in volts

Note that you cannot use milliamperes in this formula. The milliamperes must be converted to the basic unit of amperes before it will work in the formula.

Here is an example of the use of Ohm's law: If the dry cell in **fig. 2** has an EMF of 1.5 volts and the lamp's filament has 30 ohms resistance, then the current flowing must be:

$$I = \frac{E}{R} = \frac{1.5}{30} = 0.05 \, amps$$

A value of 0.05 amps might also be expressed as 50 mA, or 50,000 μA, and even 50,000,000 nA. We will be using Ohm's law again and again. Be sure you know the formula.

The resistance of the tungsten filament in the lamp is not constant: the resistance varies directly with its temperature. The filament, when hot and glowing, will have a resistance many times its resistance when cold. Electronic components known as resistors, however, are made of substances that maintain their constant resistance whether operated cool or warm. Such substances are said to have a zero temperature coefficient of resistance. Tungsten has a positive

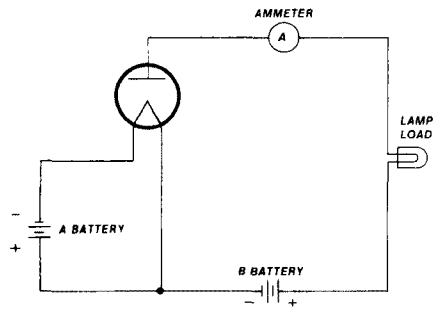


fig. 5. Vacuum diode with a filament or A-battery, a plate circuit or B-battery, ammeter in the plate circuit, and a lamp as the load.

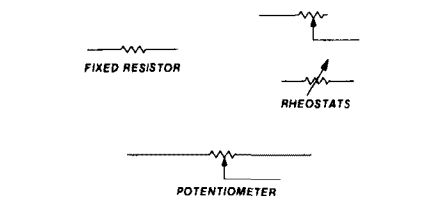


fig. 6. Symbols for fixed resistor, two ways of indicating rheostats, and a potentiometer.

temperature coefficient. In fact, most metals have positive temperature coefficients; carbon and other semiconductors have negative temperature coefficients. Thus, fixed-value resistors are usually made of both carbon and metals to produce the desired resistance as well as a nearly zero temperature coefficient.

Fixed-value resistors are usually constructed in tubular form with connecting wires out each end. They may range in length and diameter from perhaps 0.25 × 0.1 inch (7 × 2 mm) for the smaller sizes (0.1-watt, as discussed in the next section) to about 0.7 × 0.3 inch (17 × 8 mm) for medium sizes (2-watt types). Wire-wound types may be up to several inches long and an inch in diameter. There are all manner of intermediate sizes and wattages for fixed resistors. They are usually covered with an insulating (nonconducting) material.

There are variable resistors which consist of a contact arm that can be moved across an uninsulated resistance. If the variable resistor has a movable arm and only one end of the resistor is used, the device can be called a rheostat, **fig. 6**. If connections are made to both ends and the sliding arm, the device is known as a potentiometer. Potentiometers are used

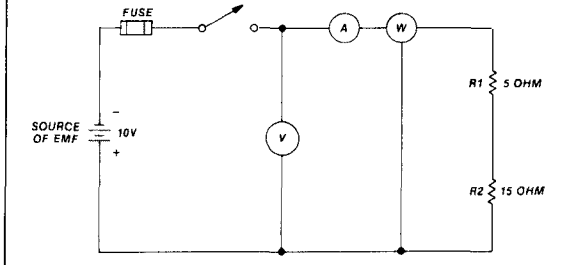


fig. 7. Circuit to be investigated for currents, voltages, and powers.

as voltage dividers in most applications, such as volume or gain controls on amplifiers or receivers.

power and energy

The term watt was used in conjunction with resistors. Watts of power indicate the energy that a resistor can safely dissipate without overheating. To determine power in watts we normally use the formula:

$$P = EI$$

where P = power in watts (W)
E = EMF in volts
I = intensity of current in amps

As an example, consider **fig. 2** again. If the voltage of the dry cell is 1.5 volts and the current through the lamp is 0.05 amps, the rate at which energy is being dissipated by the filament is $P = EI$, or 1.5 (0.05), or 0.075 watt. Note that we say the rate (which involves time, t) at which energy is being dissipated. This is because a watt is a volt times an ampere ($P = EI$), and an ampere is a coulomb-per-second (C/s, or Q/t).

If we remove the time (second) from a power computation we are left with pure energy. Thus, energy can be expressed as

$$energy = \frac{EI}{t}$$

which divides the time out of the right-hand part of the equation. If an ampere is a coulomb-per-second, and the second is cancelled, then energy must be equal to EQ (volt-coulombs). A volt-coulomb is commonly termed a joule, or a watt-second. (In the watt-second the second is added to cancel out the time in the watt.) Remember that energy is timeless and power is a rate.

Let's see how many things we can determine from the circuit shown in **fig. 7**. First, there are three new components shown, a fuse, a voltmeter (V) across

the circuit, and a wattmeter (W) in "series" with the circuit and also across or in "parallel" with the circuit. The 1-amp fuse has a wire inside it which will melt if more than an ampere flows through it. The voltmeter is across the source of voltage as soon as the switch is closed. It indicates the EMF of the source in volts. The wattmeter must consider both voltage and current at the same time ($P = EI$). It must be connected in series with the circuit to obtain the current value, and across the circuit to determine the voltage value. It considers both of these factors and indicates the product of the two in watts. Also, we have two load resistors connected in series across the source. The total resistance the source sees is $5\ ohms + 15\ ohms = 20\ ohms$.

When the switch is closed, the voltmeter reads 10 volts. The ammeter reads $I = E/R$, or 10/20, or 0.5 amp. The wattmeter reads $P = EI$ or 10(0.5), or 5 watts. Assuming the meters require almost no power to operate them, every second the source would be delivering 5 joules of energy to the two resistors. Between the two resistors, 5 watts are being dissipated. But, how much does each resistor dissipate? Let's apply what we have been discussing so far.

We know that the current through the two resistors is 0.5 amp, and since they are in series, R_1 must have 0.5 amp flowing through it, the same as R_2 has. Therefore the voltage drop across R_1 must be $E = IR$, or 0.5(5), or 2.5 volts. With 2.5 volts across R_1 and 0.5 amp flowing through it, the power being dissipated must be $P = EI$, or 2.5(0.5), or 1.25 watts. What would a voltmeter read if it were connected across R_1? If across R_2? How much power is being dissipated by R_2? You have all the information needed to compute this. Before reading on, try answering these three questions. (There are at least two ways of finding two of the answers.)

A voltmeter would read a 2.5-volt voltage drop across R_1. If there is a voltage drop of 2.5 volts across R_1 and the source is 10 volts, then there must be the difference, or 7.5 volts across R_2, right? You can also compute the R_2 voltage drop by $E = I_{R_2}R_2$, or 0.5(15), or 7.5 volts. If the total power being dissipated is 5 watts and R_1 is dissipating 1.25 watts, then R_2 must be dissipating the difference, or 3.75 watts. You could also compute the R_2 power by $P = EI$, or 7.5(0.5), or 3.75 watts.

Suppose R_2 were shorted out (copper wire connected across it). Why would all of the meters read zero after the switch is closed for a second? The answer is that the 1-amp fuse would blow out, but why? According to Ohm's law, the current flow in the circuit would be $I = E/R$, or 10/5, or 2 amps. Since the fuse is rated 1-amp it would melt when fed a 2-amp current. This would produce an open fuse, and an open circuit, even with the switch closed. The fuse is a protective device. Magnetic or other types of circuit breakers could be used in place of the fuse, and could be reset after the short-circuit is removed from the circuit. The usual radio fuse is to be a glass or other insulation material with metal caps at the ends and a fuse wire running down the center of the tube.

We might consider the power formula, $P = EI$, as being the fundamental way of determining power. However, by substituting the Ohm's law formulas into this power formula we come up with two other equally important power formulas. Consider using the IR portion of the Ohm's law formula $E = IR$ in place of the E in the $P = EI$ power formula:

$$P = EI \text{ becomes } (IR)I, \text{ or } P = I^2R$$

Similarly, by substituting the E/R part of the $I = E/R$ Ohm's law formula for the I in the power formula:

$$P = EI \text{ becomes } E(E/R), \text{ or } P = \frac{E^2}{R}$$

So, if you remember $E = IR$ and $P = EI$, by a little algebraic manipulation of the letters of the two formulas you can come up with six very useful formulas.

Refer back to **fig. 7** again. Try using the $P = I^2R$ and the $P = E^2/R$ formulas to determine the dissipation of R_1 and R_2. You should obtain the same answers as were computed above. Come on now, try at least a couple of formulas on R_1 or R_2!

alternating current

Up to this point the current that has been flowing in our circuits is known as direct current, or dc. When it flows it always moves in the same direction (− to + for electron current), and at the same strength or amplitude. If a variable resistor is added in series with a dc circuit the current varies as the resistance value changes. This produces varying dc, or VDC. In radio circuits all power supplies produce dc. When this dc is fed to amplifiers or oscillators these circuits usually change the dc to VDC, or if the current drops down to zero periodically, it becomes pulsating dc, or PDC. The graphs of **fig. 8** illustrate dc, VDC, and PDC, in which the amplitude of the current or voltage is plotted (vertically) against time (horizontally). In (a), once the current or voltage starts it continues at the same amplitude. We sometimes call this smooth dc. In (b) the current or voltage varies periodically higher and lower. In (c) the current or voltage actually stops periodically, making

pulses of dc. The pulses may be smooth-curve shaped, square-wave shaped, or saw-tooth shaped, depending on what is producing the pulsations.

Most radio circuits deal with dc (either VDC or PDC) and alternating current, or ac. Alternating current is produced by sources which have their EMF alternating from one direction to the opposite for some reason. For example, a transistorized oscillator circuit produces an output with an ac component as a result of the dc fed to it from its power supply. Any load on the oscillator will have current flowing through it in one direction for a fraction of a second, and then the current alternates and flows through the circuit in the opposite before alternating again. The current continues to alternate as long as power is fed to the oscillator circuit. Ac can be graphed as in fig. **9**. In (a) two cycles of sinusoidal, or sine-wave-shaped, ac are shown. In (b) two cycles of square-wave ac are graphed, and in (c) two cycles of saw-tooth ac are shown. The ac that we will be most interested in at this time is sine-wave ac. This is the form taken by ac generated from radio oscillators, transmitters, by utility companies, and by electro-mechanical ac generators which are properly termed alternators.

In ac work a full cycle is considered as having 360 degrees. Therefore a half cycle will consist of 180 degrees, and a quarter cycle will have only 90 degrees, fig. **10**. If the ac cycle is a perfect sine-wave, at 30 degrees (also 150, 210, and 330 degrees) the amplitude of the voltage or current will be exactly 0.5 of the maximum value. At 60 degrees (also 120, 240, and 300 degrees) the amplitude of the wave will be exactly 0.866 of the maximum, or peak value. You will find these 0.5 and 0.866 values in a Table of Natural Trigonometric Functions, or on a slide rule, or they may be obtained from more advanced pocket calculators. You can find sine values given for every tenth of a degree for the first 90 degrees. The second, third, and fourth 90-degree quadrants will have the same values as the first 90 degrees.

If all of the sine values for each degree of the first 90 degrees are added and this total is divided by 90, the average value of the sine-wave would result. For sine-wave ac this will always be 0.636 of the peak value. Can you see that the average value of a square-wave ac would have to be 1.0 or equal to the peak value? The average value is usually considered only in power supplies and in meters.

A much more important value is the root-mean-square, RMS, or effective value. The RMS comes from taking the square root of the average (mean) of the squares of the sine values for each of the first 90 degrees of the sine curve. This results in a factor of 0.707 of the peak value for sine-wave ac. This 0.707 factor is very interesting because it represents the equivalent dc voltage that would be needed to produce the same amount of heating in a resistor as it

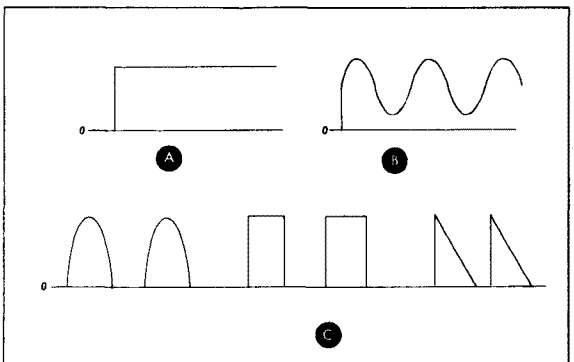


fig. 8. Various types of currents or voltages, (A) dc, (B) VDC, and (C) possible types of pulsating dc.

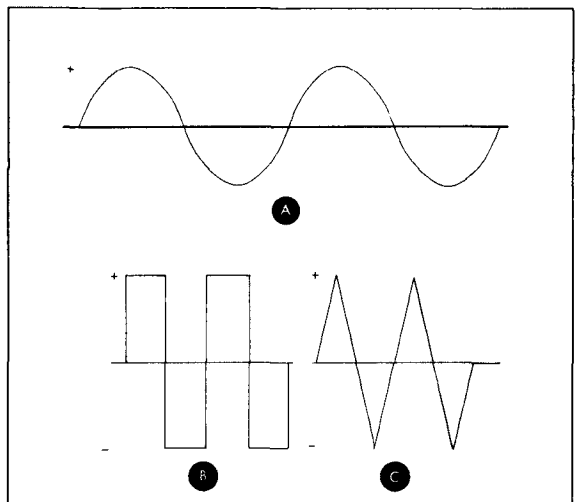


fig. 9. (A) Two cycles of sinusoidal ac. (B) Two cycles of square-wave ac. (C) Two cycles of sawtooth-wave ac.

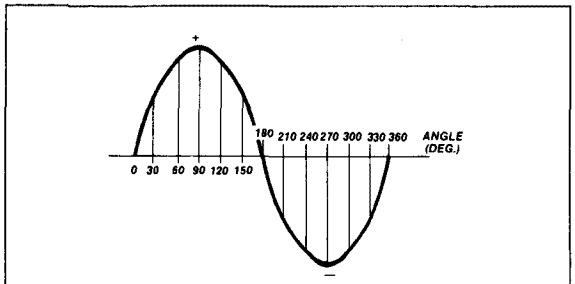


fig. 10. One cycle of sine-wave ac.

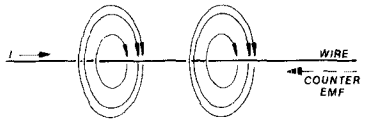


fig. 11. Magnetic field surrounds a current-carrying wire.

table 2. Frequency bands

audio frequencies	15 Hz to 20 kHz (kc)
power frequencies	50, 60, and 400 Hz (cps)
electromagnetic radiation (EMR)	
extremely low frequencies (ELF)	30 to 300 Hz
super-low frequencies (SLF)	300 to 3000 Hz
very-low frequencies (VLF)	3 to 30 kHz
low frequencies (LF)	30 to 300 kHz
medium frequencies (MF)	300 to 3000 kHz
high frequencies (HF)	3 to 30 MHz (mc)
very-high frequencies (VHF)	30 to 300 MHz
ultra-high frequencies (UHF)	300 to 3000 MHz
super-high frequencies (SHF)	3 to 30 GHz
extremely-high frequencies (EHF)	30 to 300 GHz

produced by the sine-wave ac voltage. For example, a sinusoidal 20-volt-peak ac voltage will produce the same heating effect as will *20 (0.707) = 14.14 volts dc*. The RMS, or effective value, puts dc and ac on an equal basis for many things. You will find that the 120-volt ac sold to you by your utility company is actually (1/0.707)(120), or 1.414 times 120 volts. It has a peak value of about 170 volts. So, if you want to insulate something to prevent your 120-volt RMS from sparking, it will be necessary that the insulation stand at least 170 volts, and preferably two or three times 170 volts.

Can you see that the RMS, or effective value, of a square-wave ac would be equal to the peak value, since the current or voltage is always at either the positive or the negative maximum value? Incidentally, the +100 volt peak of an ac cycle will give you just as bad a shock as a −100 volt peak will. The currents might be driven through you in opposite directions, but at the same effective or "ouch" value.

If an ac alternates 100 times a second it is said that the ac has a frequency of 100 cycles per second (cps), or 100 hertz (100 Hz). The human ear can hear sound waves developed by a loudspeaker being fed all frequencies from about 15 Hz up to about 20,000 Hz (20 kHz). Older persons, however, may have difficulty hearing above 12 or 15 kHz. The audible frequencies are called audio frequencies. Ac currents of between 15 Hz and 20,000 Hz are needed to produce air-wave vibrations of these frequencies, which the ear can recognize as sound. Dogs and other animals may hear sounds up into the 25 to 30 kHz range, sounds which are inaudible to humans.

Some of the common bands of frequencies are listed in **table 2.** Previously used abbreviations of kilocycles (kc) and megacycles (mc) are indicated.

Amateur Radio bands fill in the medium through extremely high frequencies bands. When we *speak* of "radio frequency" we mean rf frequencies from 10 kHz through 300 GHz (VLF through EHF). Microwaves are usually 1 GHz through 300 GHz.

inductance and transformers

Radio circuits involve dc sources, resistances, coils, capacitors, and transistors or vacuum tubes. A coil is just what its name implies, a piece of wire usually coiled around a tubular form made of an insulating material. It will be found that if a smooth dc current is flowing through a straight piece of wire, **fig. 11**, a stationary field of force will be developed around the wire. We can represent this magnetic field by drawing a few circular field lines around the wire. With the current flowing from left to right we indicate the field direction as coming out below the wire, passing upward on this side of the wire, passing over the top, and going down behind the wire. Arrowheads may be drawn on the field lines to indicate relative field direction, as shown.

If the current decreases, the field collapses back into the wire. As the current increases, the field expands further outward. The interesting thing about these expanding and contracting lines of magnetic force is that they induce a voltage in the wire as they expand and collapse. If the current is flowing from left to right and is increasing in amplitude, the magnetic field expands and induces a voltage of its own in the wire itself, but in a direction opposite to the source voltage and the circuit current direction. This reverse-direction induced voltage is called a counter-EMF. The counter-EMF acts to prevent a rapid current increase in the wire.

When the magnetic field collapses as current decreases, the counter-EMF is now developed in the direction of the current flow, tending to increase the circuit current. Whatever the current wants to do, the counter-EMF developed in a wire tries to counteract that effect.

If the wire is coiled, **fig. 12**, the field lines of each turn add together to form a concentrated field in the

core of the coil. The end of the coil where lines of force emerge from the core is called the north pole (*N*) of the coil. Where the lines enter the core is the south pole (*S*) of the coil. The coil in this case can be called an electromagnet. An air-core coil's magnetic strength can be increased by a factor of thousands by winding the coil on an iron core or ferrite core (a powdered iron-oxide compound bound together with an insulating substance). The more turns and the more current, the more ampere-turns — and the more magnetism developed in the core.

A relay utilizes an electromagnet, fig. **13**. A few volts and relatively little current applied to the coil creates a magnetic field that pulls down an iron armature, against the tension of its return-spring. This closes a circuit between points A and C. When the relay switch is opened the magnetic lines collapse back into the coil and the armature is pulled back upwards by the spring, breaking the contact between points A and B. Relays are used to open or close

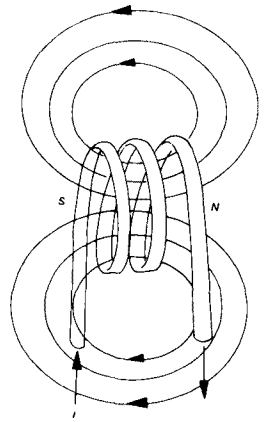


fig. 12. A coil becomes an electromagnet when current flows through it, developing north and south poles.

remote circuits, particularly when high currents or high voltages are involved.

The single armature and two-contact relay shown is called a single-pole-double-throw (SPDT) type. With only one contact, the relay would be a single-pole-single-throw type (SPST). With two armatures and four contacts, the relay would be a double-pole-double-throw (DPDT) type. Both relays and switches are made in SPST, SPDT, DPDT, as well as more complicated forms. A relay coil must be fed dc, VDC, or PDC for it to hold its armature down. If ac is used across the coil, the core will be alternately magnetized in one polarity and then in the other, which

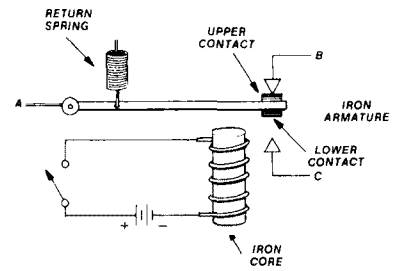


fig. 13. Essentials of a SPDT relay.

causes the armature to vibrate. However, if half of the top of the iron core piece is encircled with a copper ring, there will be an induced current in the ring that produces its own field which tends to hold the armature while the magnetic fields are alternating. This makes an ac relay.

Any wire or coil of wire is said to have self-inductance because it induces counter-EMF into itself. A coil is often referred to as an inductor. If an inductor has a 1-amp-per-second increasing current fed to it, and this results in 1 volt of counter-EMF, the inductor is said to have an inductance of one henry. The symbol for inductance is L, and the symbol for its unit of measurement, the henry, is H. Inductances used in radio may range from several henrys in choke coils to milli-, micro-, nano-, and picohenrys. They all store energy in their magnetic fields when current is flowing through them. When the current stops, the energy in the fields is returned to the inductor wires.

The straight-core, or solenoid, type of coils shown so far have a tendency to allow their fields to expand a considerable distance from them, causing interference with nearby circuit operations. This can be reduced by shielding the coils by placing them in aluminum cans. If the core is made in a toroidal (doughnut) shape, **fig. 14**, all of the field lines are essentially contained in the core material and there are no external lines leaking out into the surroundings. Many modern tuned circuits in radio equipment now use toroid coils, since they require no shielding.

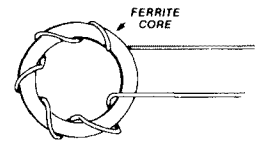


fig. 14. Toroidal inductor has minimal external field.

One of the important components in radio is the transformer. A simple transformer consists of two wires laid side by side, **fig. 15**. When the switch is closed, current flows in the "primary" wire, developing a counter-EMF in it. However, the expanding magnetic lines of force also induce an EMF into the "secondary" wire as they cross it. This produces a pulse of current through the load resistor across the secondary. When the switch is opened, the field around the primary collapses and in so doing induces an opposite-direction EMF in the secondary wire, and another pulse of current flows through the load resistor. Thus, one pulse of primary current produces one cycle of ac in the secondary circuit.

A much more efficient transformer has its primary and secondary wires wound on either a straight core or on a toroidal core, **fig. 16**. If the primary winding has 200 turns and the secondary has 400 turns, the transformer will step up the ac component of any voltage fed to the primary by a factor of two. We say the transformer has a voltage step-up ratio that is directly related to the number of turns on the primary and the secondary. If there are fewer turns on the secondary than on the primary the transformer has a step-down ratio.

The current ratio of a transformer is just the opposite of its voltage ratio. If there are more turns on the primary and fewer on the secondary, the secondary current will be greater than the primary. This is because the product of the primary E and I (remember, $P = EI$) will always be slightly more than the product of the secondary E and I, the difference being due to core losses and other inefficiencies. Since the power output can never exceed the power input, the power ratio is usually considered to be about 1:1 for all iron-core transformers.

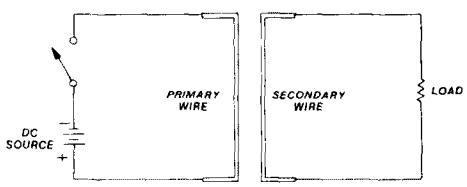


fig. 15. Simplest form of transformer.

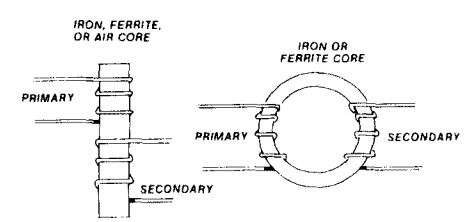


fig. 16. A more efficient transformer and toroidal transformer.

Power frequency and audio frequency transformers use laminated iron cores (made of multiple, insulated thin sheets) to reduce eddy current losses in the core. Their secondaries are usually wound right over the primary windings. Radio frequency transformers use air or, in many cases, ferrite cores to reduce hysteresis loss, which is an energy loss that results from the flipping over of magnetic iron molecules when the primary current alternates and rernagnetizes the core in the opposite direction. Primaries and secondaries are usually separated slightly.

Iron-core inductors are used as choke coils in power supplies, making use of their ability to oppose any current changes. They produce a smoother dc from varying or pulsating dc. Air and ferrite inductors are used in radio frequency choke (RFC) coils, tuned circuits, and when coupled together, in rf transformers. Symbols for the various inductor applications are shown in **fig. 17**.

capacitance and capacitors

Capacitance exists whenever two conductors of any kind are separated from each other by some form of insulator. Two wires laying next to each other have a small capacitance between them. A component made to have capacitance is called a capacitor (originally called a condenser). A basic capacitor is shown in **fig. 18**. It consists of two metal plates separated, in this case, by air. When the DPST switch is closed, the top plate is connected to the negative terminal of the battery and the bottom plate to the positive terminal. Electrons rush through the lamp into the top plate, and electrons on the bottom plate are repelled and made to flow into the positive terminal of the battery. This charges the capacitor plates, and an electrostatic field develops between them.

If the capacitor is large and battery voltage is high enough, the charging current may pulse the lamp on for an instant. When the switch is opened, electrons will be trapped on the plate of the capacitor and it remains charged. If the left terminal of the lamp is now connected to the positive plate of the charged capacitor, a discharge current will flow through the lamp, possibly pulsing it on again for an instant. The greater the resistance of the lamp the slower the capacitor will charge and discharge.

The insulation between the plates, in this case air, is called the dielectric. It would be possible to draw lines across the dielectric to represent the electro-

static field, just as lines were used to represent magnetic fields. Magnetic and electrostatic fields are not the same, however, although both will be developed in all working radio circuits. Inductors store energy in their magnetic fields. Capacitors store energy in their electrostatic fields.

If a capacitor can store one coulomb of charge in itself when across 1 volt of EMF, it is said to have one farad (F) of capacitance. The farad is a very large value of capacitance. We usually use capacitors with microfarad (μF), or picofarad (pF) ratings in radio circuits.

Variable capacitors are usually made by using intermeshing plates. When the plates are completely intermeshed the capacitance is at its maximum. When the plates are completely unmeshed the capacitance is at its minimum. Usually, one set of plates is fixed in position; these are called the stator plates. The movable plates are called the rotors. Adjustable — as opposed to variable — capacitors depend on their plates being compressed together by screwdriver action.

If the air-dielectric capacitor shown in **fig. 18** has a sheet of mica, paper, ceramic, or plastic slipped in between the plates, the capacitor will store more electrons than it would otherwise, given the same source voltage. The capacitor will have greater capacitance because these new dielectric materials can accept more lines of electrostatic force than air can. Such dielectric materials are said to have a higher dielectric constant. Air has a dielectric constant of 1. Mica, waxed paper, and plastics have constants that are between 5 and 10. Ceramic dielectrics may range in the thousands. All of these capacitors will be nonpolarized. That is, they may be connected into a circuit without regard as to which leads are used where. They may be used in ac, dc, VDC, or PDC circuits, although paper capacitors are not used in circuits where the frequency is expected to exceed about 2 MHz.

Two high-capacitance types of polarized capacitors are electrolytic and tantalum capacitors. They are made of sheet aluminum plates held apart by some material and dampened in a chemical solution. When manufactured they are connected across a dc voltage or potential and the plates "form," developing an oxide on one of the plates. This oxide layer is very thin and has a very high dielectric constant. Such capacitors always carry a polarity marking (+) on one lead and must be connected in the circuit according to this polarity. If not, they will deform, heat, and burn out. These capacitors can not be used in ac circuits: only in dc, VDC or PDC circuits.

Fixed capacitors may be made in flat oblong or flat round shapes, or they may be in tubular form. They may have their leads emerging from the far ends. If made to be soldered into printed circuit (PC) boards, the leads will both come out the same side of the device. Capacitors range from tiny BB-shot size to the size of a small book.

Capacitors are used in conjunction with inductors in tuned circuits, both audio frequency and rf. Their ability to oppose any change in voltage allows them to be used to smooth (filter) varying or pulsating dc. They are also used to pass ac-effects without any direct connections, and are used to "bypass" ac energy to ground. Symbols of various types of capacitors are shown in **fig. 19**.

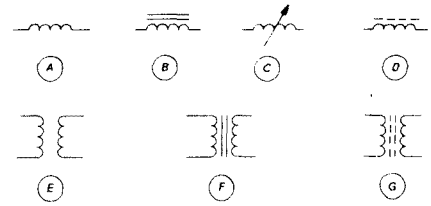


fig. 17. (A) Air-core coil. (B) Iron-core coil. (C) Variable air-core inductor. (D) Ferrite core inductor. (E) Air-core transformer. (F) Iron-core transformer. (G) Ferrite-core transformer.

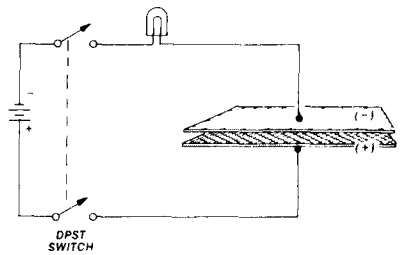


fig. 18. Basic air-dielectric, two-plate capacitor in charging circuit.

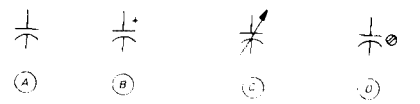


fig. 19. Symbols of (A) fixed capacitor, (B) polarized capacitor, (C) variable capacitor, (D) screwdriver variable capacitor.

ham radio

simplifying the multipurpose UHF oscillator

Some modifications making use of inexpensive and easy-to-find components

An earlier article[1] in *ham radio* described a low-power, voltage-tuned oscillator operating above 1000 MHz. It was designed primarily for use as a local oscillator in microwave television converters.

Two means of frequency control were described: 1) a free-running mode involving continuous tuning by means of a potentiometer, and 2) a phase-lock mode for click-stop tuning. These circuits are incapable of producing the degree of waveform coherence in a UHF oscillator for narrowband systems involving CW and SSB. In the free-running mode the circuit *Q*s are too low, and in the phase-locked-loop mode switching noise and oscillator subharmonics generated by the prescaler produce too much phase noise. In either case, however, the spectrum is clean enough for microwave TV applications.

By using more sophisticated circuitry it's possible to provide almost any degree of spectral purity. These advanced circuits are based on the oscillator described here and will be the subject of a future article. They will allow Amateurs to use CW and SSB modes in the microwave region as we do today on the high frequency-bands.

In developing the original UHF oscillator, I paid very little attention to component parts cost. I used parts on hand. Typical of this extravagance are the Plessey prescalers, which together cost about $40.00. Other examples are the tuning diode and the HP35821 transistor, which cost about $25.00 and $15.00 respectively in small quantities. Few can afford the luxury of such expensive components; those who can may find them difficult or impossible to procure in small lots.

The development work that followed my original effort was dedicated to simplification and cost reduction. These goals were to be met without sacrificing performance. Also all components were to be readily available in small quantities.

modifying the UHF oscillator

Much effort went into developing the circuit changes and making the modifications to meet the design goals. While the original electrical circuit configuration was retained, I made major changes to the PC board to accommodate new components. Those that were changed include the oscillator transistor, tuning diode, prescaler, and voltage regulator. Also, the PC board was scaled down in size to fit inside an inexpensive and readily available enclosure.

component changes

I used a Motorola MRF-901 high-frequency plastic

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transistor to replace the more expensive HP-35821 to help meet the design goals. While the MRF-901 is specified primarily for use as a low-noise amplifier and switch, it also performs very well as an oscillator. This transistor has become very popular with Amateur experimenters because of its favorable performance characteristics and modest cost in small quantities. It has a typical f_T of 4.5 GHz with 15 mA collector current. Although the pinout is intended for common-emitter circuits, I designed the UHF oscillator PC board to accept this configuration without difficulty.

A Motorola MV2201 plastic 6.8-pF tuning diode (70 cents in small lots) has replaced the expensive and hard-to-find GC type 1607 diode. The capacitance tolerance of this diode is 5.5-8.0 pF at 4.0 volts bias. The MV2101, which sells for about $1.25 and has a lower tolerance of 6.1-7.5 pF, can also be used.

The *Q* of the MV2201/2101 is low compared with that of the more expensive devices. Theoretically, a small amount of oscillator power that would otherwise be available at the rf output jack replaces the tuning-diode loss. Despite this drawback, this modified UHF oscillator described here easily provides 10 mW of rf output power. Thus, modest tuning diode *Q* is an acceptable compromise.

An RCA CA3179G 1.25-GHz prescaler replaces the more expensive Plessey types. The 3179G costs less than $10.00 each in small quantities. The RCA CA3163G, which has an identical pinout, is a suitable substitute. These prescalers divide by 256 when connected in the UHF mode.

The modified prescaler circuit is less comlex than the original one. It uses fewer components, and expensive 0.1-watt resistors have been eliminated.

The Plessey prescalers used in the original UHF oscillator[1] provided division by 40. It was recommended that an external divide-by-25 circuit be added to allow a counter to display, in kHz, the oscillator frequency in MHz. In retrospect, while the divide-by-40 circuit was a novel idea, it offered nothing in terms of oscillator performance that would justify the high cost of the prescalers. For experimental purposes, the CA3179G, which divides by 256, together with a simple conversion chart or hand-held calculator, will do just as well. Therefore, in keeping with the goal of availability and reduced cost, I decided to use the CA3179G prescaler.

You can get along without the prescaler if you have access to a digital counter that operates to about 1400 MHz. In most applications it's not necessary to display the oscillator frequency continuously, but it's useful to have the prescaler available for tune up and frequency adjustment. In my design I included a switch to disable the prescaler when not in use.

There are several reasons why I added this switch. First, I found that careful shielding was necessary to prevent small but measurable amounts of subharmonic signal power, generated by the prescaler, from appearing at the rf output jack.

Another reason for the switch is to reduce drift of the oscillator. The prescaler dissipates 325 mW of power, and 455 mW more is dissipated in the 5.0-volt series-pass regulator. The oscillator's frequency stability is considerably improved when the prescaler is inoperative; otherwise, over a period of time, the additional 780 mW of heat increases the temperature of the oscillator module and causes some frequency drift. The component most affected by temperature changes is the tuning diode.

Two voltage regulators, an MC78L12 and an MC78L05, are connected in series to provide regulated +12 and +5 volts. These regulators have become very popular with Amateur experimenters because they are inexpensive and available in small quantities. Originally the +12 volts was supplied by a 723 IC, and a separate negative supply was needed for the prescalers. The modified UHF oscillator unit requires only a single positive supply voltage of between +15 and +19 volts at a current of about 100 mA.

The enclosure for the modified UHF oscillator consists of a RACO 11.5-cubic-inch (188.4-cm^3) extension box (92 cents) at hardware stores. The RACO box is made of welded steel and is normally intended for electrical house wiring purposes. Experience has shown that the PC board containing the UHF oscillator should be mounted inside of a rigid electrostatic enclosure. At UHF, fm microphonics may occur if the box is not rigid; furthermore, a good rule is to make the box rf tight to avoid the unpleasant consequences of rf leakage.

The RACO box meets these requirements. It measures 1-1/2 inches (38 mm) high, 2 inches (50 mm) wide, and 4 inches (102 mm) long. It is open both at the top and bottom. A flat 0.074-inch-thick (1.9-mm) aluminum plate 2-1/8 × 5-5/8 inches (54 × 143 mm) is attached with four screws to the bottom of the box. Matching holes, drilled into the bottom of the box, are tapped for 4-40 (M3) screws for that purpose. The plate extends out 5/16 inch (8 mm) from the box on each side where 1/8-inch (3-mm) holes are drilled to provide means for mounting. The top of the RACO box is fitted with a 0.020-inch-thick (0.5-mm) aluminum cover with 1/4-inch (6.4-mm) flaps turned down on all four sides. Except for the oscillator line and grounding shims to be described, the top and bottom covers are the only two sheet metal parts that need to be fabricated. These relatively simple parts are illustrated in **fig. 1**.

the oscillator line

The mechanical details of the oscillator line L1 are shown in the original article and therefore will not be duplicated here. However, the line should be shortened from 2-1/16 inches (52.4 mm) to 1-3/4 inches (44.5 mm). This is necessary to compensate for the parasitic (lead) inductances of the inexpensive MV2201 tuning diode.

assembly procedure

You can make the PC board yourself from the full-scale patterns shown in fig. 2 or obtain them from Rock Engineering Supply Company, Inc., 1769 Armitage Ct., Addison, Illinois 60101. Another option is to procure a kit of parts including the PC board from RadioKit, Box 411, Greenville, New Hampshire 03048.

In simplifying the UHF oscillator, the expensive feed-through capacitors have been eliminated. All bypass capacitors are ceramic disc types except for C6, which is a 24-pF dipped mica. The schematic diagram is shown in fig. 3. C6 is soldered directly on the foil side of the board with extremely short leads. The original article describes how to prepare this capacitor before installation.

It is recommended that parts be assembled on the component side of the board first, including the voltage regulators, prescaler, the 2N5179 transistor and associated parts. Next, oscillator line L1 should be mounted on the foil side of the board. The pointed end of this inductance fits into the insulated hole near the MRF-901 transistor. The other end of L1 is supported by a 3/32-inch-thick (2.4-mm) epoxy fiberglass shim. Apply two-part, five-minute epoxy glue sparingly to the shim and each end of the line to secure them in position.

mounting the varactor tuning diodes

Because the MV2201 is equipped with wire leads, solder should be applied as close to the plastic body as possible to minimize lead inductance. The anode is soldered to the large pad under the oscillator line, while the cathode lead is bent at a right angle and soldered to the top of the line. Fig. 4 shows the installation of the diode. For operation at approximately 1100 MHz, the tuning diode should be soldered to the oscillator line at 1-1/4 inches (31.8 mm) from the collector end of the line.

mounting the PC board in the enclosure

The PC board is mounted in a RACO box about 1/2 inch (12.7 mm) from the top. It is held in place by

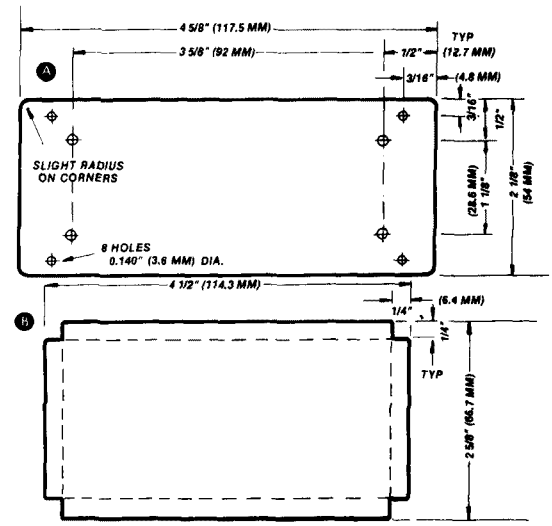


fig. 1. Construction details of the bottom plate and cover, (A) and (B) respectively, used with the UHF oscillator enclosure. Material is aluminum stock, 0.074 inch (1.9 mm) thick for the bottom plate and 0.020 inch (0.5 mm) thick for the cover. Flaps should be bent around a RACO box to form a tight fit.

means of L-shaped spring-brass shims soldered to the top and bottom of the rf output edge of the board. These shims also serve as rf grounds. I used scissors to cut my shims from a discarded piece of weather stripping; then I bent them at an angle of about 120 degrees using a bench vise as a makeshift brake. The dimensions of the L are 1/8 × 1/2 inch (3.2 × 12.7 mm); the small dimension is soldered to the board. The board is secured in position by means of 4-40 (M3) screws through both the wall of the box and the shims.

There are two holes located at the rear edge of the board, which are intended for through-grounds. Insert a short piece of tinned copper busbar in these holes, fold over and solder on each side.

operating frequency range

I built the modified UHF oscillator primarily to operate at its fundamental frequency in the range between about 1100 and 1200 MHz. However, by adjusting the position of the tuning diode on the line, the range can be moved up or down as in the original design. It's also possible to use frequency multipliers for higher-frequency operation, as described in the original article.[1]

output coupling

The output-coupling circuit is similar to the original

one; however, a 3/16 inch-diameter (4.8 mm) powdered iron slug inserted in the output coupling loop and screwed to the board has been added to increase the coupling. The slug acts as a magnetic dipole, which aids the output current in the loop. Although it may seem surprising, carbonyl C iron made by Cambion (Cambridge Thermionic Corporation), which is normally intended for use at much lower frequencies, gave very good results. Power output was measured to be in excess of 10 dBm with the slug.

The rf coupling loop is formed from 3/16-inch (4.8 mm) wide 12-mil (0.3 mm) shim stock. The rf output jack should be mounted in a 3/8-inch-diameter (9.5 mm) hole centered on the middle knockout. The rf coupling loop terminates on the large pad under the BNC connector. The pad acts as an rf bypass capacitor and also allows dc power to be brought into the box by way of the coaxial center conductor.

To ensure a good rf output termination, a 3/16-inch-wide (4.8 mm) piece of copper foil is soldered to the flat on the threaded portion of the BNC connector. The other end of the copper foil is soldered to the ground foil on the edge of the PC board under the BNC connector. It is important that this ground foil be made as short as possible.

test and adjustment

Provisions have been included on the PC board to monitor the MRF-901 collector current for tune-up purposes. Temporary leads should be tack soldered to the doughnuts on each side of the gap in the PC conductor leading to the + 12V oscillator pad. When the adjustment is complete, a jumper will be soldered across this gap, as illustrated in **fig.** 4.

The feedback capacitor, not shown, is made of 1/8-inch-wide (3.2 mm) copper foil. One end is soldered to the emitter, while the other end extends out over the top of a 1/32-inch-thick (0.8 mm) epoxy fiberglass insulator cemented with epoxy to the top of the oscillator line. See **fig.** 4 for details.

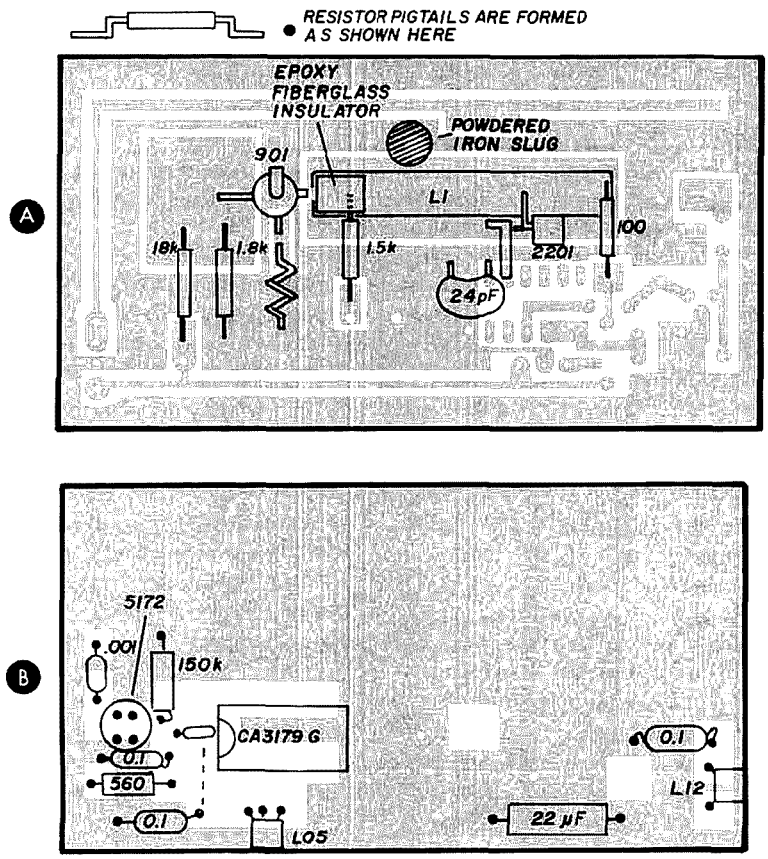


fig. 2. Printed-circuit board layout. The foil side is shown in (A); component side in (B).

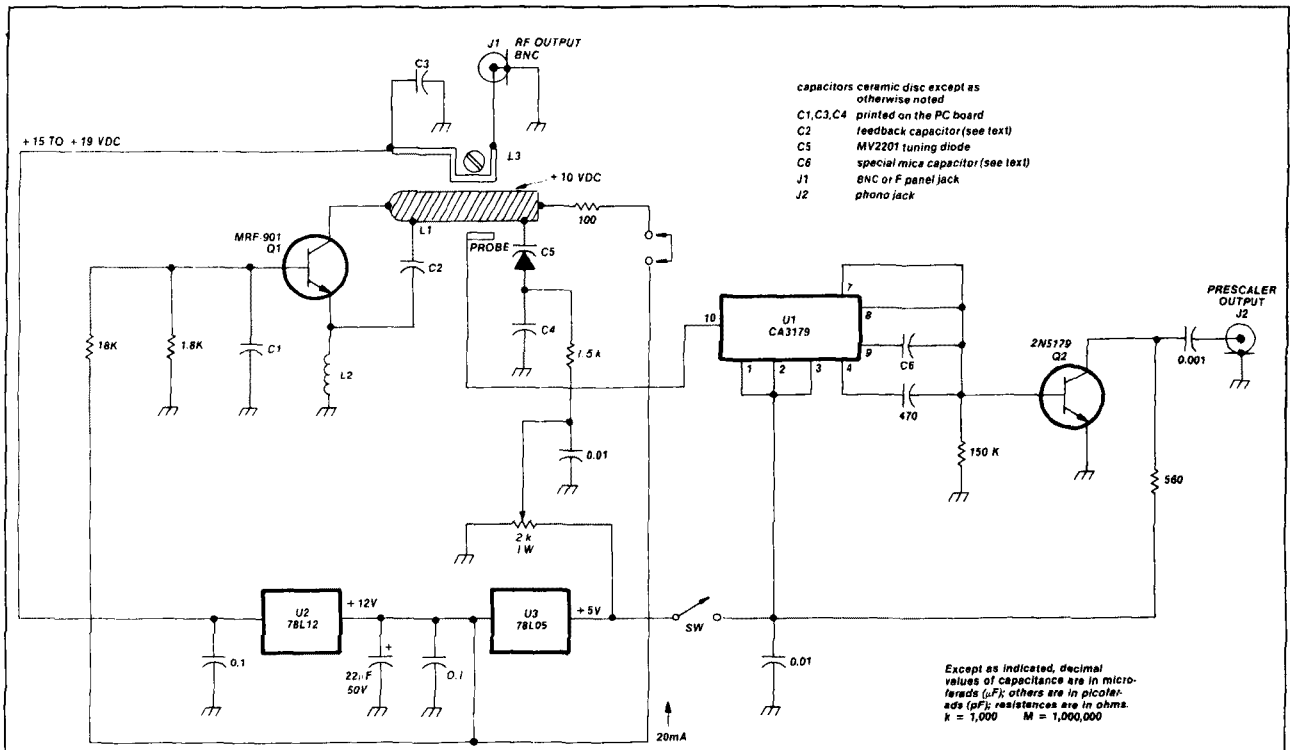


fig. 3. Schematic diagram of the improved UHF oscillator. The more expensive oscillator transistor, tuning diode, and prescaler used in the original circuit have been replaced with the components shown. Oscillator line L1 in the original design has been shortened from 2-1/16 inches (52.4 mm) to 1-3/4 inches (44.5 mm).

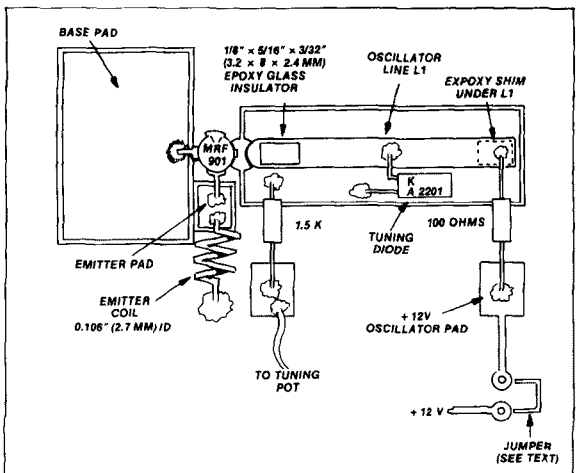
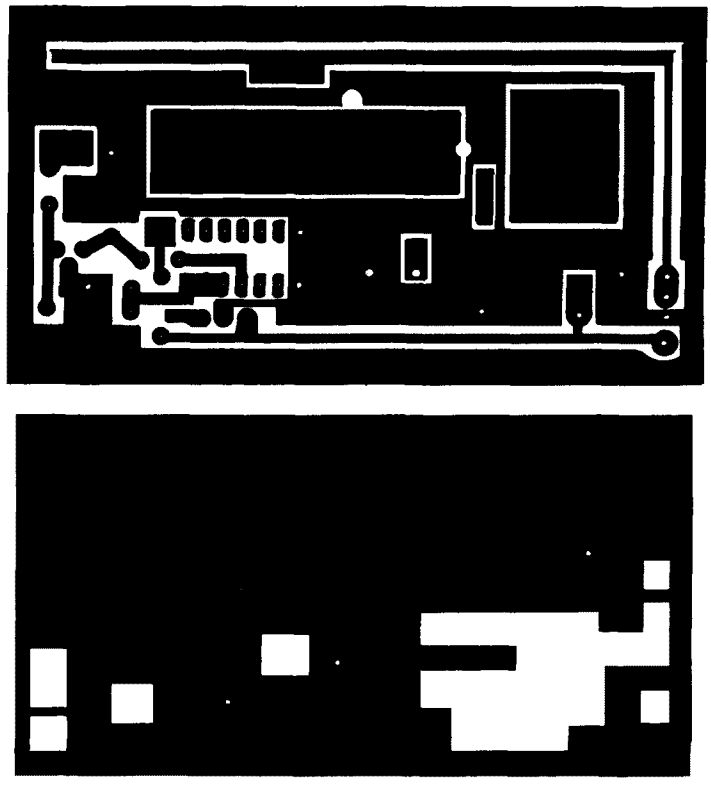


fig. 4. Details of oscillator assembly. Feedback capacitor C2 in fig. 1 is made by bending the unused emitter lead of the MRF-901 up and over the top of the transistor. A 1/4 × 1/8 inch (6.4 × 3.2 mm) piece of copper foil is then slid under the emitter and over the epoxy insulator and soldered to the emitter. (This capacitor is not shown in the drawing. See text for adjustment.)

tune-up procedure

The procedure for tuning up the MRF-901 is somewhat different than for the HP35821B transistor used in the original model. First of all, a 100-ohm current-limiting resistor (which also acts as an rf choke) tends to maintain a relatively constant collector current. The 1.8k and 18k biasing network should set the collector current between 15 and 20 mA for most MRF-901s. *Do not* permit the collector current to exceed 30 mA. To reduce the collector current, increase the value of the 18k resistor to 20 or 22k as required.

The oscillator frequency is highly dependent on the capacitance between the emitter and collector. To adjust frequency, set the tuning pot output voltage to zero (12 volts *tuning-diode* bias). Connect a counter to the prescaler output jack; adjust the value of the feedback capacitor until the oscillator frequency is equal to the desired high-end frequency. Either clip the foil or bend it back on itself to increase frequency. Note that the counter readout corresponding to a frequency of 1100 MHz should be 4.2969 MHz. After making this adjustment, apply a very small amount of epoxy cement to the feedback capacitor to secure it to the epoxy insulator.



Etching pattern for the printed-circuit board.

The tuning range of the modified oscillator is smaller than with the original model — about 3 percent of the center frequency instead of ten percent. This is due primarily to the relatively high capacitance of the tuning diode. This range may be increased by using two tuning diodes in series.

The tuning range of the new oscillator has deliberately been reduced to permit use of a single-turn instead of ten-turn tuning pot. This is in keeping with the goal of cost reduction.

You may want to provide means to tune the UHF oscillator from a remote location. If so, remove the tuning pot and insert a phono jack in its place. Connect a 470-ohm, 1/4-watt resistor from +5 volts to the junction of the 1.5k resistor and the 0.01 μF bypass capacitor. Then connect the junction to the center conductor of the phono jack. The 2k pot can then be located at the far end of a shielded cable. Solder a phono plug on the near end.

conclusion

The UHF oscillator as described in reference 1 leaves something to be desired in terms of component cost and availability, which explains the reason for further development. Although its performance is outstanding in most respects, the original model was complex and difficult to construct. Also there was measurable rf leakage because some of the components were not totally shielded. Nevertheless, it proved to be a good starting place.

The modified UHF oscillator overcomes the problems of the original unit while retaining its good points. Because the RACO box is rugged and provides full shielding, stability and drift are negligible by comparison. For example, the warm-up drift of my modified oscillator operating in the free-running mode measured 650 kHz. After stabilizing in four minutes from a cold start, the frequency drifted only 0.06 percent at 1100 MHz. When buffered with a 3-dB pad, the effect of changing the load from a short to an open circuit through all possible angles caused a frequency change of less than 1.5 percent. Finally, despite the fact that the MRF-901 has less power-handing capability than its predecessor, it delivers a full ten milliwatts into a 50-ohm load.

Without compromising the important performance characteristics, the UHF oscillator can now be constructed easily with components that are readily available at a fraction of the cost of the original unit. The design goals specified at the beginning of this article have been met.

reference

1. Norman J. Foot, WA9HUV, "A Multipurpose UHF Oscillator," *ham radio*, December, 1980.

ham radio

ham radio TECHNIQUES

Bill Orr W6SAI

Making a crystal from a pair of eyeglasses! From time-to-time I receive interesting letters based on material in this column, and I'd like to share some of them with you.

G.W. Thomas, G5YK, of Suffolk, England, writes, "I was very interested to read your April issue...on 10 meters.

"I was also on 10 meters in those days and the first India-Europe contact was made on February 10, 1929: I established contact with VT2KT on that day using about 50 watts.



fig. 1. Charlie Atwater, nu2JN, and his pioneer 10-meter transmitter. Charlie's 1928-1929 experiments helped open this new Amateur band. Using a UX-210 driving a UX-852, Charlie's transmitter delivered about 80 watts into a Zeppelin antenna. Unfortunately, the sunspot cycle was on the downward trend. After a few exciting months 10 meters went dead, and interest lapsed for nearly eight years.

"I was also fascinated in the making of a crystal from a quartz slab. The price of a crystal in those days was more than my weekly wage, so I found a way of making one cheaply and with less effort. From an optician's shop I bought old quartz spectacle lenses and slowly and painstakingly ground them down to 80 meters. They were marvelous, and a friend (then G5YX) and I had a little business going as a sideline for a short while. Oh, those were the days!"

Charles Atwater, W2JN

A real old timer passed away a short time ago: Charlie Atwater, W2JN. Located in Upper Montclair, New Jersey, Charlie established the first-ever, 10-meter transatlantic QSO, with ef8CT in France. Ten meters had until then been considered a worthless band. W2JN exploded this idea around 1928 with a *two-hour, 100-percent contact*. Using an experimental license, Charlie made this record before the 10-meter band was opened for general Amateur use. The nu2JN transmitter (**fig. 1**) is an eye opener today! Doesn't look much like a Kenwood, does it?

W1BVL was there!

A note from Dick Briggs, W1BVL, says, "Your article in the April, 1981, *ham radio* was of great interest to me, particularly your description of W1XM's 10-meter crystal-controlled transmitter of 1928. The four-tube driver unit using 201A tubes was built and used for my thesis at MIT in May, 1927. In 1928, a year after my graduation, the unit was used as described by Howard Chinn in November, 1981, *QST* magazine.

"At that time little was known about frequency doubling with vacuum tubes. My thesis made an analysis of the operating parameters. Also it was found that frequency changers could be made somewhat regenerative to enhance the gain per stage.

"My first DX QSO on 10 meters was with Bill Eitel, W6UF, on October 21, 1928, at 3:40 pm, EST. My transmitter was a tuned-plate, tuned-grid (TPTG) oscillator with a UV-203A with about 80 watts input from a chemical rectifier. The antenna was 70 feet long slanting up from 30 feet to 55 feet and a counterpoise wire slanting down from 30 feet to 8 feet.*

"All the above brings back memories of those old times. I am now a retired vacuum-tube engineer and do consulting on microwave magnetrons."

the final word on 10 meters

George Elliott, W6ENC, sends the final word on 10 meters — a beautiful copy of the *Ten-Ten International Net* bulletin celebrating 50 years of 10-meter activity. The complete story of the famous nu2JN contact is in the bulletin, plus many other articles of interest to the 10-meter operator. The *Ten-Ten International Net* monitors 28,800 kHz daily except Sundays and publishes an interesting quarterly bulletin, chock-full of articles of interest to 10-meter ops. Full information on the net and the bulletin can be ob-

*Also known as the "up and out" antenna – a version of the sloper. A popular antenna of the 1930s was "40 up and 40 out." Sometimes the counterpoise was run close to the ground and was called a "worm warmer." It also warmed people who came in contact with it. Editor.

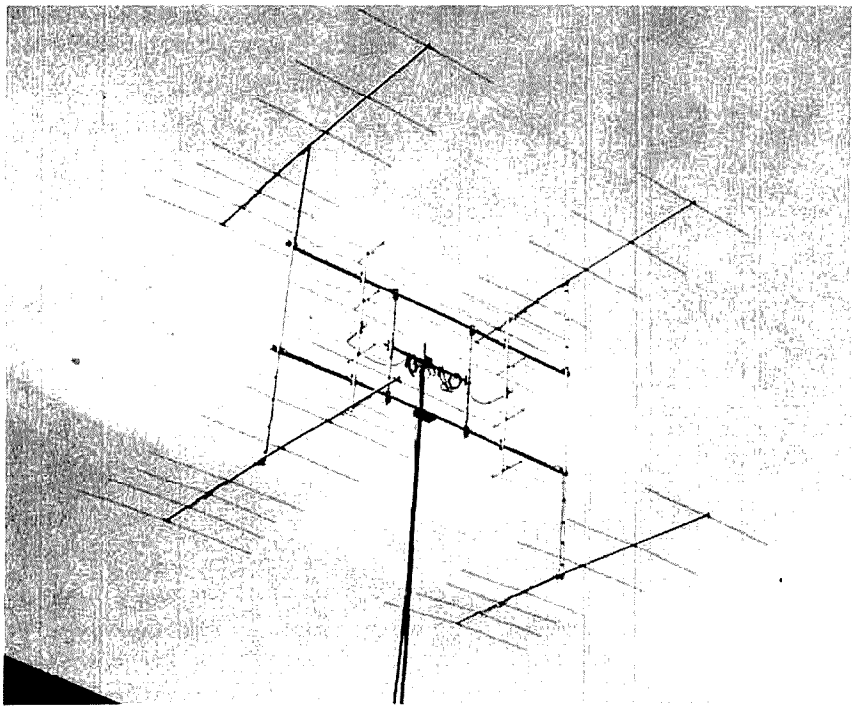


fig. 2. This photo explains why K6QXY has such a robust signal on 6 and 2 meters. The 6-meter array is composed of four seven-element KLM LPY Yagi antennas. Inside the array is the 2-meter beam, which consists of two twenty-element expanded collinear arrays.

tained from W6ENC, George Elliott, whose QTH is 942 Victoria Drive, Arcadia, California 91006. I would imagine that two postage stamps included in your letter to George would help.

To become a member of *Ten-Ten* you have to work some of the present members on 10 meters. I'm sure George can bring you up to speed on that, too.

how to be LOUD on 6 and 2 meters

Have you ever heard the ear-splitting signal of Bob Magnani, K6QXY, on 6 or 2 meters? No? Then you must be off the air. Bob has an outstanding signal, and the pictures he sent me tell why. **Fig. 2** shows the present installation, which consists of four seven-element KLM LPY Yagi antennas spaced one wavelength apart for 50 MHz. Estimated gain over a dipole — about 17 dB. Inside the 6-meter array is the 144-MHz array, which consists of two twenty-element expanded collinear arrays providing about 16 dB gain over a dipole.

Fig. 3 shows Bob's new antenna project, which seems to me to be comparable to building the pyramids of Egypt. This shows the base assembly for his new moonbounce antenna. It consists of three *Rohn* 25 towers in a triangle, 10 feet (3 meters) on a leg. In the center of the triangle is a stressed steel and concrete subbase that has 6 cubic yards (4.6 cubic meters) of concrete in it, going down 10 feet (3 meters). The top pour, which will cover the excavation, will have 17 cubic yards (13 cubic meters) of concrete in it, for a total of 23 cubic yards (17.6 cubic meters). Two towers will go up about 80 feet (24 meters), tied together every 10 feet (3 meters). An antenna, steerable in azimuth and elevation, will go at the top. It is planned to have eight seven-element KLM LPY antennas providing a power gain of about 21 dB, with six-

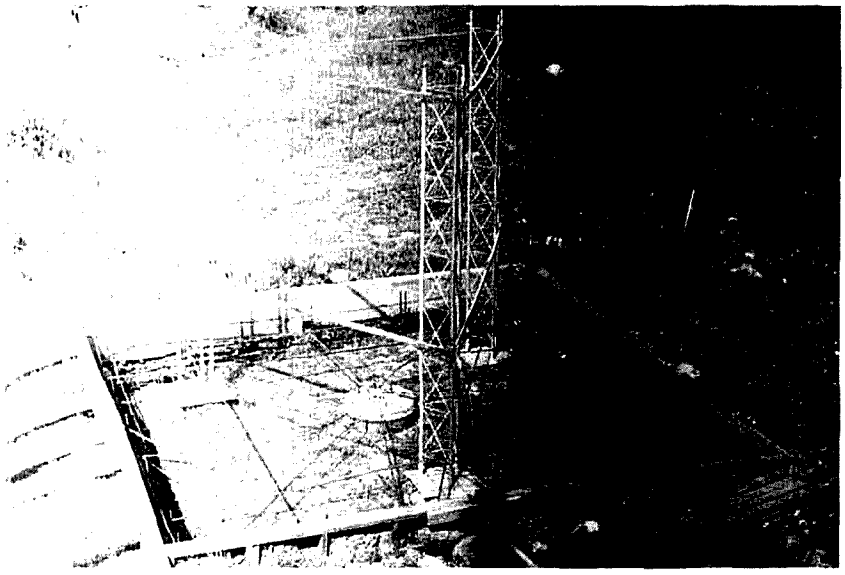


fig. 3. The base for K6QXY's new moonbounce antenna consists of three lattice towers arranged in a triangle. The first sections are up in the photo. The towers will go up to about 80 feet (24.4. meters), tied together every 10 feet (3 meters). Twenty-three cubic yards (17.6 cubic meters) of concrete will be poured into the base.

teen fourteen-element "Junior Boomers" for 144 MHz nestled inside the bigger antenna. This will provide about 25 dB gain on 2 meters.

So if you haven't heard K6QXY yet, you soon will!

a long wire antenna for field day

"Wait until next year!" That's the cry of the Field Day enthusiast. And sure enough, the antennas for 1982 will be bigger and better than those used in 1981 for portable work.

Bob Walton, W6CYL, has the perfect scheme for getting a longwire antenna up in the air with a minimum of fuss and bother. He uses an arm-brace slingshot. This is a device that has a lightweight aluminum frame mounted at the bottom of the vertical handle, which rests back on the forearm and reduces the force on the handle when you draw back on the rubber tubing bands for a long shot into a tall tree.

Bob places a 6-ounce (170-gram) fishing line sinker on a heavy monofilament nylon line wound on the reel of a take-apart Japanese-imported trout rod. This setup will take about 200 feet (60 meters) of line. Bob mounts the pole and reel on a ground stake and releases the drag on the reel. Then, with the sling shot, he shoots the sinker up and over a tree using the fishing line as a messenger cable to pull up a longwire antenna. He puts an egg insulator on the end of the antenna wire so that he can see when the end is getting near the tree leaves and branches.

Bob has also tried the bow-and-arrow technique of shooting an antenna into a tree. He says that works, too, but it requires more expertise to spot the antenna wire where you want it. Bob says that you can buy a reel of braided copper antenna wire (part number AS-207/CRT-3) at Fair Radio Sales, Box 1105, Lima, Ohio 45802.

After he gets the monofilament line safely up into a tree, with the sinker down at ground level, he attaches the braided copper wire to the line, unreels the wire and pulls in the sinker and line. Up she goes! When he's finished operating, he releases the fishing line from the tie-down at ground level, and reels in the braided copper wire. In the event of a snag, he pulls on the wire and the nylon line breaks, freeing the balance of the wire.

Bob says, "Operating from a trailer, as I often do, requires searching for a parking spot that will permit a longwire antenna. Here, trees are ham's best friends. And when you put up the antenna, stand by for a rash of CBers who descend upon you with all kinds of questions. Some even report inventing radio and the thrill of working skip, etc.!" Bob shows how it's done in **fig. 4.**

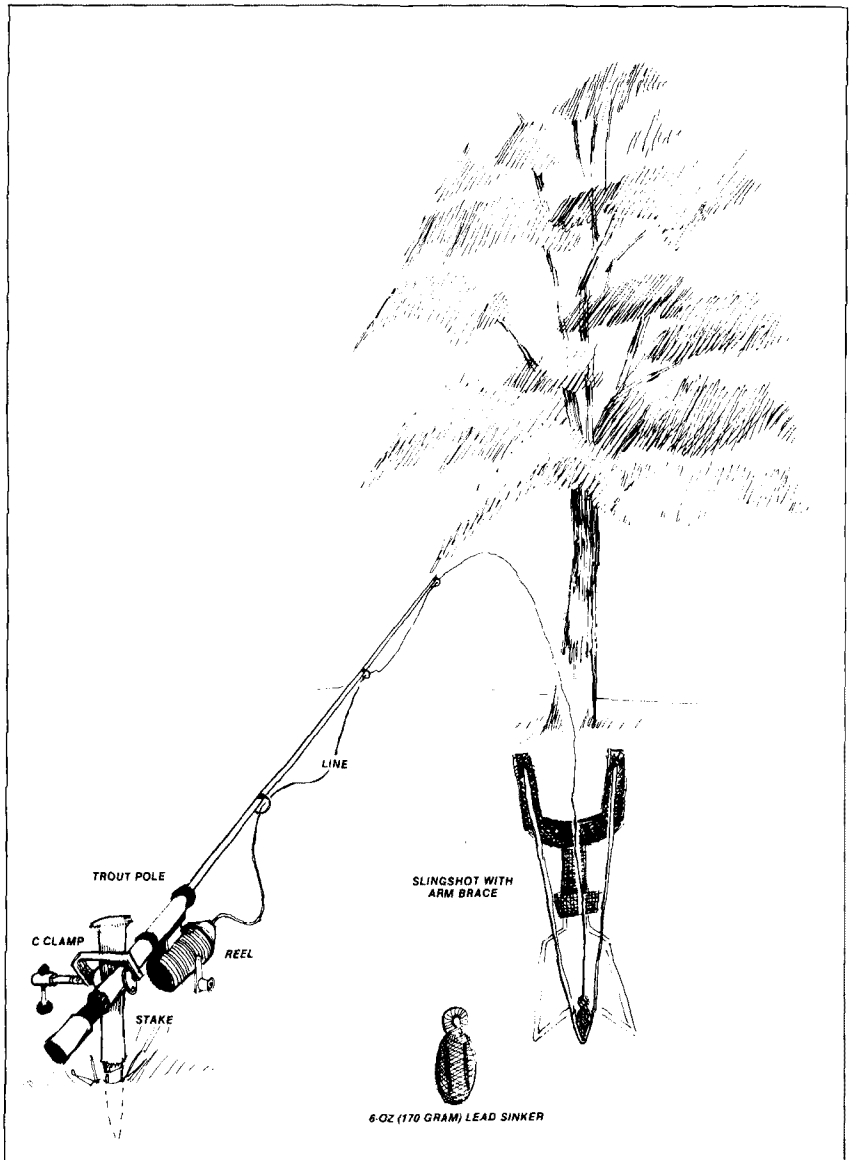


fig. 4. The W6CYL slingshot technique for erecting a portable antenna. Nylon fishing line on a trout pole is attached to lead sinker, which is then catapulted over nearby trees using an arm-brace slingshot. Bob prefers this to the bow-and-arrow technique. Try it out next Field Day.

the 2-meter quad at K3AC

K3AC, Malcolm Williams, lives in a high-rise apartment, as do many other Amateurs. The building frame is steel, and the use of an indoor antenna is out of the question. But K3AC puts out a powerful 2-meter signal with the aid of his portable four-element quad antenna. In a matter of minutes the quad can be assembled and placed onto the porch. And in bad weather, the quad can be used indoors, shooting out through the sliding glass doors (fig. 5). Dimensions for a quad of this type, cut to 146 MHz are: reflector loop, 21-1/2 inches (54.6 cm) on a side; driven element loop, 20-1/4 inches (51.4 cm) on a side; two director loops, each 19-1/4 inches (49 cm) on a side. Reflector-to-driven-element spacing is 16 inches (40.6 cm); driven-element-to-director spacing is 13 inches (33 cm). Spacing between directors is 13 inches (33 cm).

For vertical polarization the driven loop is broken in the middle of one vertical side and fed with a random length of RG-58/U coaxial line. The line is brought back to the boom and then run down the supporting mast. For horizontal polarization, the driven loop is broken in the middle of the bottom for the coaxial line. The reflector and director elements are the same in either case; they "don't know" the polarization of the driven element!

A duplicate of this quad beam is easy to build. The boom can be a 4-foot (1.2-meter) length of 1-inch (2.54-cm) diameter wood dowel rod, varnished to protect it from the weather. The loops are built from lengths of 1/4-inch (0.6-cm) diameter wood dowel rods, fitted into holes drilled in wood blocks. The blocks, in turn, are drilled to press-fit over the boom. The loops are made of No. 20 (0.8 mm) enameled wire.

To space the loops properly on the X-frame, the wire can be temporarily positioned with the aid of short pins pushed into the dowel rods. Once the position of the wires has been determined, the dowel tips are drilled to pass the wire element. The loop is made taut by pulling the dowels out of the holes in the center block a bit before epoxy cement locks the dowels to the block.

The array is collapsed by sliding the loops off the dowel boom. For a more portable affair, the loops themselves can be made to collapse.

There's no reason the vertical mast can't be lashed to the balcony and rotated by hand. K3AC mounts his quad on a small case, which provides a base and container for the quad when it is not used.



fig. 5. The compact 2-meter quad at K3AC is ideal for the apartment dweller. Sometimes Mal uses it indoors, shooting the signal through the sliding-glass doors. See text for dimensions and construction details.

what about your antenna?

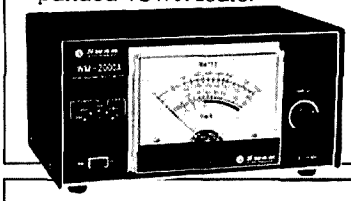
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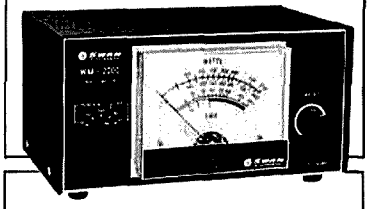
SWAN METERS

THE TOP OF THE LINE

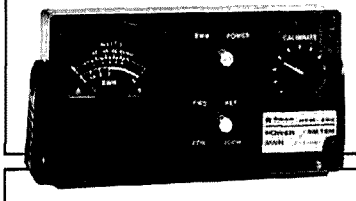
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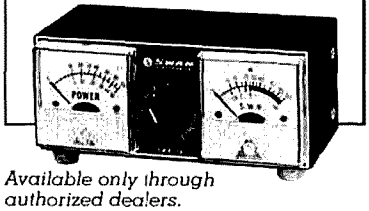
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the half-wave vertical

A 40-meter DX antenna without a radial-wire ground system

A current-fed vertical antenna, such as a quarter- or five-eighths-wavelength monopole, must have a radial-wire ground system for maximum efficiency.[1-3] This is known as a groundplane.

the groundplane

What is the purpose of this groundplane? Will it provide the low-angle radiation necessary for working distant stations? The radial-wire ground system under the antenna must provide a low resistance to reduce ohmic losses in the system. The ground-loss resistance, referred to the base of the antenna can, by a groundplane, be made low with respect to the system radiation resistance. For a quarter-wave vertical the radiation resistance is approximately 36 ohms. The radiation efficiency is therefore high. The radial-wire groundplane system is therefore important, since the length and number of radials, as well as the conductivity of the ground, determine this terminal loss resistance.

The parameters of the antenna, however, to launch sky waves at low angles above the horizon extend to distances well beyond the antenna and its ground system. In fact, the conductivity of the ground, fifty or more wavelengths from the antenna, is important in that it influences the vertical radiation pattern of the antenna. And this effect is significant, especially for launch angles of less than 10 degrees above the horizon.

Fig. 1A shows the theoretical vertical radiation pattern for a 6-MHz quarter-wave antenna over poor, good, and very good ground (sea water). The pattern for an antenna over very poor ground, but with an extensive ground system,[4] is shown in **fig. 1B.** It is clear that, while the radiation efficiency of the antenna is improved by using a ground screen, the power gains for elevation angles less than 10 degrees becomes vanishing small.

the half-wave antenna

An alternative approach is to use a half-wave radi-

By John S. Belrose, VE2CV, 3 Tadnoussac Drive, Aylmer (Lucerne), Quebec, J9J 1G1, Canada

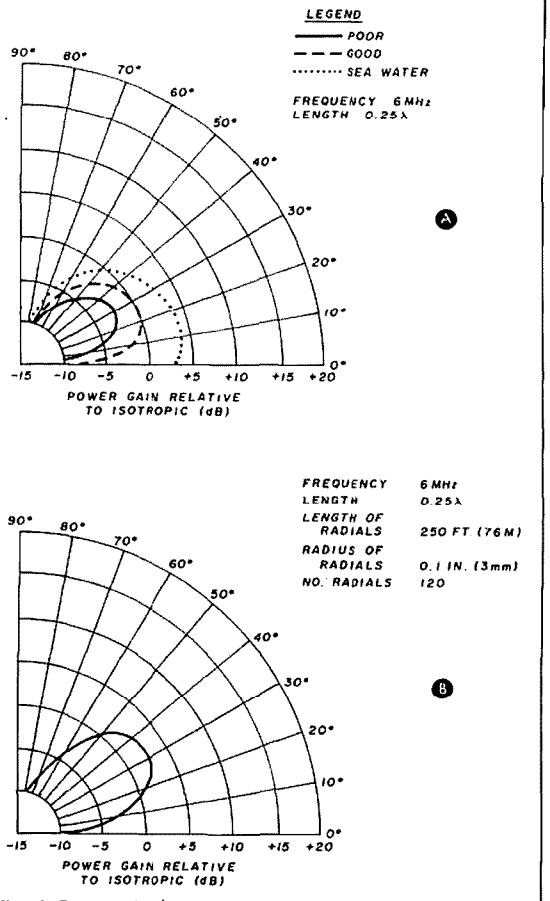


fig. 1. Theoretical radiation pattern for a quarter-wave antenna over poor, good, and very good ground (A) and over very poor ground but with an extensive ground system (B).

ator. Since its radiation resistance is high compared with the ground-loss resistance, the radiation efficiency can be high, even without wire ground radials. The base resistance of a half-wave antenna depends on its height-to-diameter ratio. For a tower antenna, the base radiation resistance is about 500 ohms; for thin wire antennas this resistance is several thousand ohms. Furthermore, if the antenna feedpoint is elevated from the ground, the influence of the finite conductivity of the ground on the input impedance of the antenna is even further reduced. The antenna will therefore radiate with good efficiency, even with no ground screen at all. Of course, the far-field vertical radiation pattern, especially at low elevation angles, is affected by the conductivity of the ground as discussed above; but we have little control over this except to erect the antenna over a salt marsh or over alkaline flats in the prairies.



Erecting the home-built coaxial sleeve antenna at a field-day site (top). Lower photo shows the antenna in operating position.

The coaxial vertical, or sleeve antenna, (**fig. 2**), is a half-wave radiator. This antenna is used extensively at VHF. It can also be used effectively at high frequency, at least for frequencies greater than 7 MHz. The coaxial sleeve is composed of a cage of four wires connected to the top of a tower, insulated from ground and the tower but connected by a skirt wire at the lower ends. The antenna is fed by a coaxial

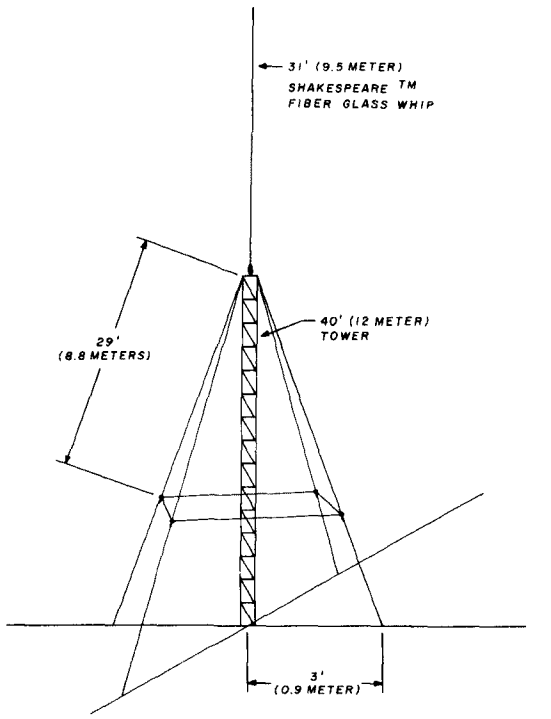


fig. 2. The 40-meter coaxial-sleeve antenna. The coaxial sleeve is composed of a cage of four wires connected to the top of a tower, insulated from ground and tower, but connected by a skirt wire at the lower ends.

cable that runs up the center of the mast. The outside conductor of the coax is connected to the top of the tower; the center conductor is connected to the base of a free-standing, base-insulated whip at the top of the tower. (For base-station use, the tower should be grounded for lightning protection.)

The optimum height, measured from the center of the antenna above the ground, is one-half wavelength, since the antenna and its image are then separated by one wavelength. This is the height for maximum gain, which for a perfectly conducting ground, would be 6.27 dB over a dipole in free space. However, this height can be decreased to about 0.35 wavelength before ground losses appreciably affect the input impedance.[5]

antenna fundamentals

A vertical antenna of physical length or height, H, is related to its electrical length, G, by a factor k:

$$H = kG \qquad (1)$$

where H is height
k is a factor (less than 1)
G is electrical length (degrees)

That is, the physical height, H, is *less* than the electrical height, G, due to a) end effects and b) the velocity of propagation of the wave along the radiator, which is less than its velocity in free space. Usually G will be one-quarter, one-half, or five-eighths wavelength (90, 180, or 225 electrical degrees). If G is measured in meters rather than in degrees, (as for example, we express wavelength in meters), then the physical height, H, or in this case, h, will also be in meters.

The factor k depends on the length-to-diameter ratio (H/D) of the radiator and on its electrical length. **Fig. 3** shows the experimentally determined relationship between these parameters. In **fig. 3** the percent increase of G over H is plotted versus the electrical diameter, D, (degrees), for a very wide range of values of D. Thus for thin antennas, this factor is approximately 5 percent, and for fat antennas, the percent increase is considerable. The experimental values were obtained from various sources. I measured those labeled 2 in **fig. 3** for first and second resonance. Previous investigators, for example Brown and Woodward,[6] got into difficulty for the larger values of D because of the capacitance of the base plate since the disk they used, which closed the bottom of the cylindrical radiator, formed a shunt capacitance across the terminals of the radiator. In my measurements I used rods rather than tubes, and the radiators were tapered to a point at their bottom end (but the taper was over a distance small with respect to the length of the radiator) to minimize this effect. I have used the curves in **fig. 3** for antenna design. The curve for $G = 225$ *degrees* probably lies midway between those for $G = 90$ *degrees* and *180 degrees*.

Towers are not usually of circular cross section. For triangular towers $d = 0.48b$ **(2)**

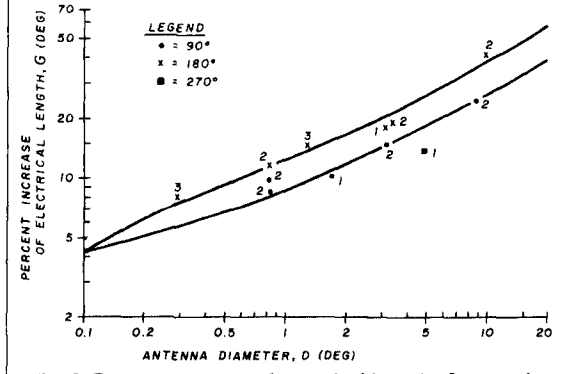


fig. 3. Percent increase of electrical length, G, over the physical length of a monopole antenna at height H. Points labeled 2 were measured by the author for one-quarter and one-half wavelength resonance. Other points were taken from various sources.

and for square towers

$$d = 1.18b \quad (3)$$

where b = face width of tower
d = effective diameter of the tower

design of the coaxial-sleeve antenna

Suppose we design a coaxial-sleeve antenna for a frequency of 7.15 MHz ($\lambda = 984/fMHz = 137.6$ *feet or 42 meters*, and *a quarter wavelength = 34.4 feet*, or *10.5 meters*). The antenna arrangement is sketched in **fig. 2**.

The Shakespeare™ whip had a diameter of 1-1/4 inches (31.8 mm) at its base, and 1/4 inch (6.4 mm) at the top of the radiator. The effective diameter is therefore $\frac{1.25+0.25}{2} = 0.75$ *inch, or 19 mm (0.0625 foot, or 0.02 meter)*.

Thus $D = \frac{0.0625\,(360)}{137.6} = 0.16$ *degrees*. In metric terms, $D = \frac{0.02\,(360)}{42}$.

The percent lengthening is therefore approximately 5 degrees, or $k = \frac{1}{1.05} = 0.95$. However, for fiberglass whips, the conducting wires are embedded in fiberglass. The velocity of propagation is therefore further reduced by the velocity of propagation in fiberglass, which is about 0.95 times the velocity in free space. Hence

$$k_{eff} = 0.95k$$
$$= 0.95\,(0.95) = 0.9$$

The length of the whip is therefore: $0.9\,(34.4) = 31$ *feet (9.5 meters)*.

The effective diameter of the coaxial sleeve is estimated as follows. The top of the sleeve is the diameter of the supporting tower, which for a triangular tower 8 inches on side is $0.84\left(\frac{8}{12}\right) = 0.56$ *foot (0.17 meter)*.

The four wires of the cage that form the sleeve are tied to stakes forming a 3-foot (0.9-meter) radius about the base of the tower (see **fig. 2**).

Visualize these tie points to form the corners of a square, which at ground level has a side length of $2\sqrt{2} = 4.24$ *feet (1.3 meters)*. Thus the effective diameter is $1.18\,(4.24) = 5$ *feet (1.52 meters)*. The effective diameter at the end of the sleeve is approximately $\frac{30}{40}\,(5) = 3.75$ *feet (1.14 meters)*. The average effective diameter of the sleeve is therefore $\frac{3.75+0.56}{2} = 2.15$ *feet or 6.57 meters*. (that is, 5.6 degrees). Hence (see **fig. 3**), the percent lengthening for $D = 5.6$ *degrees*, $G = 90$ *degrees is 19 percent*. The antenna factor $k = \frac{1}{1.19} = 0.84$. The length of the sleeve is therefore 0.84 times the length of a free-space quarter wavelength, or $0.84\,(34.4) = 29$ *feet (8.8 meters)*.

The antenna* was built according to these dimensions, and indeed it was resonant in the middle of the 40-meter band. Since the input impedance of the antenna (which was not measured) is expected to be closer to 72 ohms than to 50 ohms, the feed cable should be RG-11/U. If 50-ohm cable is preferred (RG-8/U), the feeder cable should be cut so that it is an integral multiple of one-half wavelength (a cable one wavelength long would be 90.83 feet, or 27.7 meters). This is because such a transmission line, regardless of its impedance, transfers to the feedpoint the terminal impedance without introducing reactance.

a practical antenna

The antenna that we constructed for use at a field-day site is shown in the photos. A full-wave delta loop (apex down, apex fed) was also used. This antenna has quite a different vertical radiation pattern (dominantly high angle). Switching from one antenna to the other provided reception from quite a different zone — a very desirable feature for field day.

acknowledgments

I would like to thank Harry, VE2RO, and Arn, VE2SD, for help in constructing the antenna. Thanks are also due to the field-day crew who raised the antenna, and to Geof, VE3KID, who took the photographs.

*The 40-foot (12.2-meter) tower employed is just marginally high enough, since the height of the antenna measured from its center is approximately 0.3 wavelength. Ideally, a 70-foot (21.4-meter) tower should be employed.

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DIGITAL TECHNIQUES

avoiding built-in digital-circuit problems, part one

Many problems common to analog circuits pose no problems at all for well-designed digital circuitry, but digital circuits may be subject to built-in errors caused by inattention to logic timing, improper power-supply filtering, or radio-frequency interference (RFI). Examples of some problems and cures are presented, including oscilloscope waveforms for several divider circuits. Output pulse stretching modifications are shown for dividers with low repetition rates. Attention to logic-state timing is stressed, and the "logic race" condition is explained.

Methods of improving power-supply distribution are presented, concentrating on decreasing supply-source impedance. Off-board wiring can act as an antenna for RFI, and improvements shown here demonstrate filtering methods for RFI. Adding gating with dc control lines restricts data selection. Mechanical-switch-contact bounce is shown, and a debounce circuit given. The author suggests studying past mistakes to avoid future problems. **Editor**

A nice feature of digital circuitry is that it's not sensitive to drift, noise, or realignment problems, which are common to analog designs. A good digital circuit performs the same function each time. But a few digital designs are not well executed by the designer, usually the result of lack of experience.

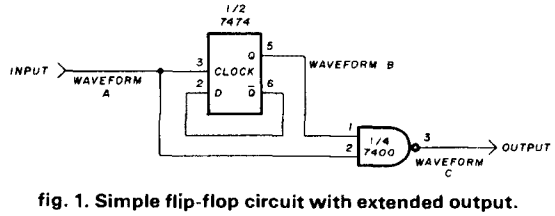


fig. 1. Simple flip-flop circuit with extended output.

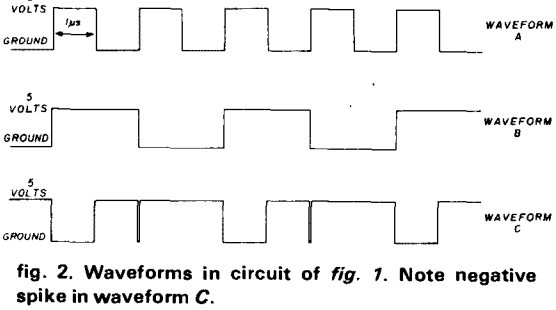


fig. 2. Waveforms in circuit of *fig. 1*. Note negative spike in waveform *C*.

One can thus "build-in" problems; and the purpose of this article is to help you learn how to "build them out".

There are several ways to spot a poor digital design: a project may work only over a limited supply-voltage range. Interchanging identical devices may not be possible, or certain portions of the circuit may be critical. Strange things may happen when switches are thrown. Worst of all, the circuit may be sensitive to rf pick-up.

Tracking down and fixing these problems can be difficult. The underlying cause may show itself only during a transition, and not be obvious from an examination of resting states. Useful troubleshooting tools are a fast multi-channel oscilloscope, good data books, and lots of experience.

Professionals have access to good scopes and also have the design experience. Good data books are available, and pitfalls are easy to avoid once understood. But the mass of data on each device may be overwhelming to the eyes of the inexperienced. So let's expose the critical factors.

The greatest design problem is poor timing. Modern logic operates with nanosecond transition and delay times. These times are so fast that they may appear instantaneous when compared with a 50-WPM keyer, for example. Nanoseconds are important, though, and the proper sequencing of logic signals is crucial to the success of a circuit design.

Many logic designs work because the designer was lucky: the arrangement of propagation delays just *barely* allowed proper sequencing. Copying such designs, using long leads, will add time delay and may make the circuit marginal. Inadequate power-supply bypassing may fail to remove glitches (unwanted, short spikes), which can make the circuit inoperative.

the logic race

A constant problem is the *race* condition. This phenomenon occurs when two or more sequence paths are mixed with improper time delays among each path. The circuit may work, but it's not clear how much margin exists and glitches may appear that affect circuitry further downstream.

A glitch-generating condition is shown in the simple flip-flop circuit of **fig. 1** and the waveforms of **fig. 2**. The flip-flop circuit could be used to generate a string of dashes in a keyer (input clock speed in this example was increased to make the negative glitch clearly visible).

By Penn Clower, W1BG, 459 Lowell Street, Andover, Massachusetts 01810

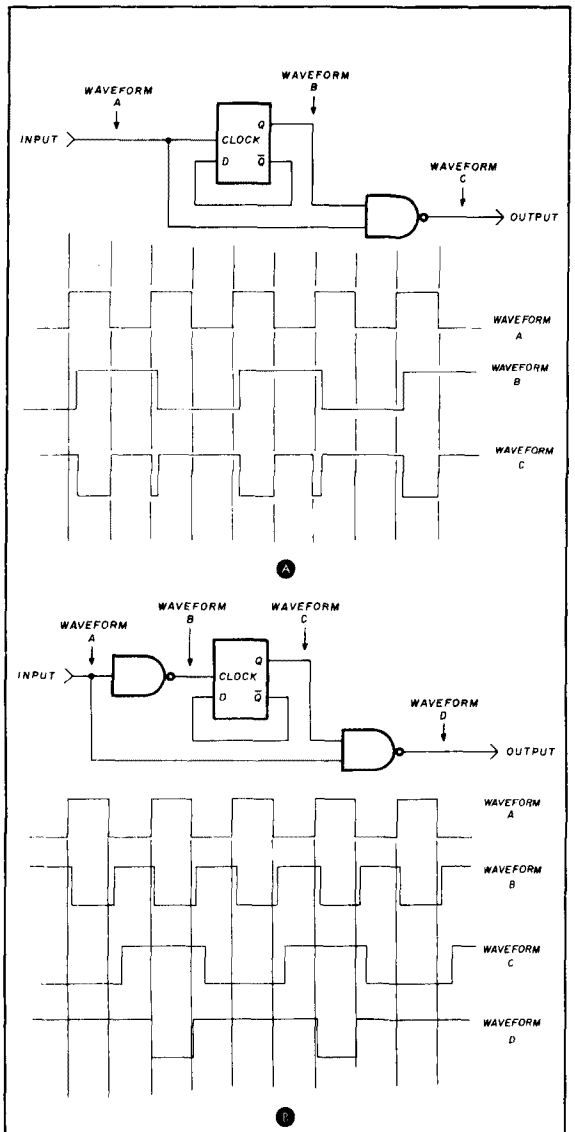


fig. 3. Using ruled paper to analyze timing. Note how propagation delays have been exaggerated to show glitch formation. Circuit of *A* is the same as in *fig. 1*; *B* adds a gate to eliminate the output spike.

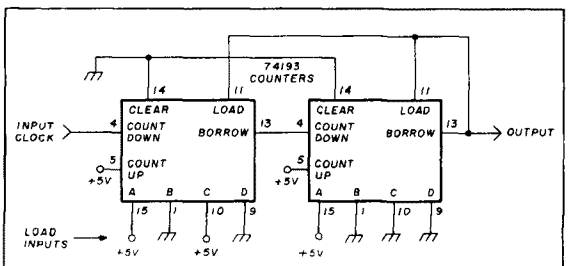


fig. 4. Divide-by-20 circuit using 74193 up-down counters.

The negative spike is the result of a race condition: the input clock signal reaches both the flip-flop and gate at the same time. Since the flip-flop has some delay in changing state, a brief time occurs when both gate inputs are high, to produce a low gate output.

Each race condition must be judged for a particular application. Some don't matter. If the circuit of **fig. 1** were used as a keyer, the CW transmitter would ignore a 50-nanosecond spike since carrier envelope response is usually several milliseconds. On the other hand, if the output were used to clock or gate some other logic, the spike would not go unnoticed! A problem spike should be modified so that the race is always won by the designer.

a simple race analysis tool

This tool is simply a piece of lined paper turned sideways. Paper lines provide time markers for the input waveform. This technique is used in **fig. 3**. It shows the original **fig. 1** circuit and timing in **A**, one solution in **B**.*

The solution toggles the flip-flop on the opposite edge and adds a gate delay to the flip-flop clock input. Output-gate inputs will "line up" without glitches. Use of this fix will depend on remaining circuitry; note that the opposite clock edge does the flip-flop toggling.

judging a race

An important point to remember is that races can result from many causes: device delays, board layout, temperature, and operating voltage, which can vary a spike width. Such races may be hard to spot because of time differences. Even a fast scope can't display a short spike at a low repetition rate. Troubleshooting may require a fast rate for test or simply the paper analysis tool. More than one device has been discarded because it was properly responding to "invisible" spikes!

the brief but necessary spike

Some medium-scale integrated (MSI) devices generate very short output pulses by design. This forces close attention to board layout because long lines can distort short pulses and cause trouble.

The divider circuit of **fig. 4** is an example. The 74193 counters are connected in a down-count mode with preset of 20. When the second stage borrow goes low, the preset condition is loaded into the counters. The input clock then counts down until both counters reach all-zero, causing the borrow out-

*Propagation delays should be taken from data books, but the paper sketch can exaggerate the delays for clarity.

put to go low, and the process repeats.

Fig. 5 shows the input and output waveforms with a 1-kHz input rate. The output *appears* to have nothing, but it *is* working.

A 74193 device has a direct asynchronous preset load feature. Borrow out is determined by all-zeros, but this is also the preset load. Width of the output pulse is determined by the propagation delays of borrow output and load: about 30 nanoseconds in this case.

Fig. 6 is an expanded time-scale version of **fig. 5**. It shows the negative edge of the 20th clock pulse in relation with the output pulse. A delaying-sweep oscilloscope is required for this brief-but-necessary spike, but other problems exist.

Distributed capacitance and series-lead inductance of long lines may distort the output and prevent proper loading. (Long lines tend to form lowpass filters.) Both counters should have borrow and load propagation delays within specification; out-of-specification device problems are covered later.* It doesn't make sense to choose a circuit requiring fast-pulse layout with a 1-kHz clock. Three added NAND gates will improve things.

improved divider with visible output

The circuit of **fig. 7** adds a set-reset latch (U1, U2) between borrow and load. U2-6 is held high by clock inverter U3. The low borrow from the second counter will flip the latch and make U2-6 low, enabling the preset load. The load will remain low for one-half clock cycle through the inverter.

Once the latch has been set and preset load enabled, the latch is reset only when the input clock goes high. The positive edge of the clock would normally toggle the counter, but the 74193 is designed to inhibit counting until the load pin returns high. This means the circuit of **fig. 7** will skip one input clock.

The input-output waveforms of fig. **8** show a visible output pulse, one for every 21 inputs. The same preset connections as in fig. 4 were used. A proper division by 20 requires a preset connection one *less* than the desired count.

Layout problems are reduced, and the output is visible, but two gates and an inverter are required. (If these are not available, another device may be chosen.)

a different device but same function

Another way out of the fast-spike problem is to

*Sometimes these problems are caused by off-brand ICs.

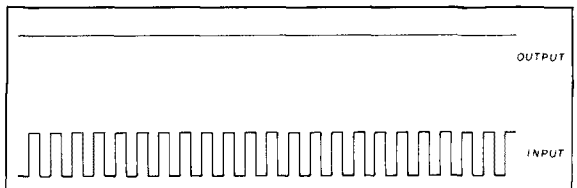


fig. 5. Input-output waveforms for the circuit of *fig. 4*. The output is too short to be visible on the oscilloscope.

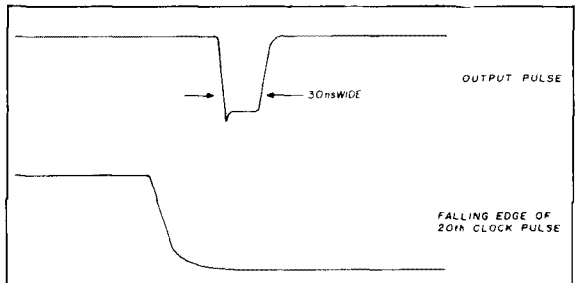


fig. 6. Expanded time trace for the circuit of *fig. 4*. Bottom trace is the negative edge of 20th clock pulse. Top trace is output pulse — too short to observe in *fig. 5*.

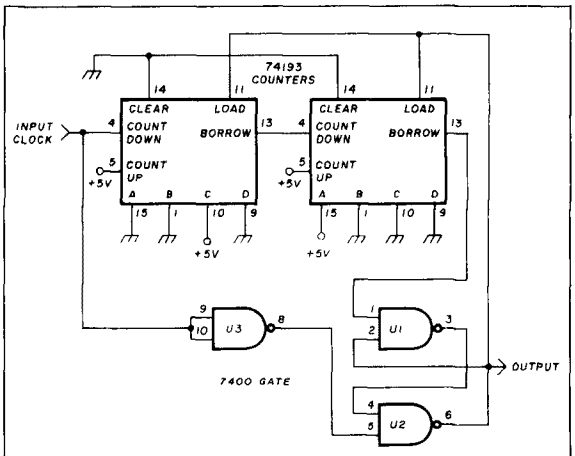


fig. 7. Divide-by-20 circuit of *fig. 4* modified to lengthen output pulse.

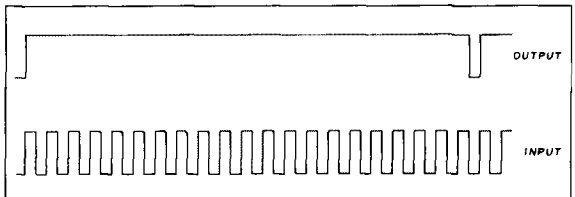


fig. 8. Waveforms of circuit of *fig. 7*. Top trace is output with width equal to negative input clock time. Bottom trace is input clock with preset connections (same as in *fig. 4*). Added gating adds 1 to the division ratio.

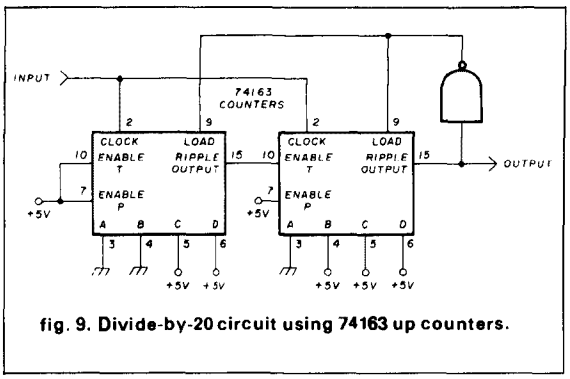


fig. 9. Divide-by-20 circuit using 74163 up counters.

design with a device such as the 74163. It features synchronous loading; the preset loading occurs only when the required clock edge is received. A divide-by-20 circuit is shown in fig. **9**, with waveforms in fig. **10**.

Operation is similar to that in **fig. 7** except that the 74163 is an up-counter. Preset is maximum count, minus desired count, minus one. It is the binary *complement* of **fig. 7**.

Ripple carry output goes high on full count, then it's inverted for the preset load input. The 74163 is designed to inhibit counting when the load pin is low. The clock enables preset loading instead, and the counters have an entire clock cycle to settle before the first up-count.

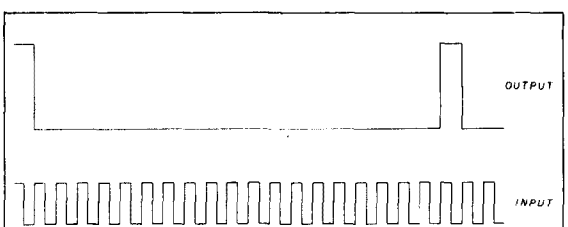


fig. 10. Waveforms of *fig. 9* circuit. Top trace is output at 2-volts per division; bottom trace is input at 5 volts per division.

reliability

The important thing to remember about these examples is that a reliable design must allow sequences in a nice, orderly fashion, with plenty of time for setup and settling. The designer must hold device speed limits and observe propagation delays. Layout and wiring problems then have easier, low-frequency solutions.

The next part of this article will show some other problems and solutions, plus methods of reducing radio-frequency interference (RFI).

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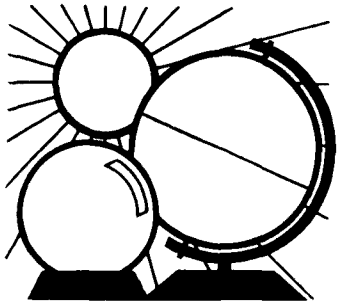
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DX FORECASTER

Garth Stonehocker, KØRYW

fall equinox propagation outlook

September, like March, is a special time of year for propagation, and therefore DX. Equinox is the reason: equal-length nights and days; the sun is directly overhead at noon on the geographic equator. At this time, with the radiation from the sun hitting the earth broadside, and because the equatorial plane of the earth and the plane of the sun's equator nearly coincide, particles from the sun's eruptions (flares) and coronal holes (thin places in the sun's gases) have a bull's-eye path to the earth. These charged particles, called the solar wind, enter the earth's atmosphere in the polar regions. They also build up in the Van Allen belts around the earth above the equatorial region. When full, the belts dump into the polar auroral zone, on the Canadian-U.S. side after about 2200 local time. This is a geomagnetic storm.

Coincident with the geomagnetic storm are three ionospheric processes that affect propagation and DX. First, the particles coming into the auroral zone ionospheric D and E regions absorb the energy from the signal, lowering the S-meter reading. Weak signals on east-west paths and few signals across the poles are the result. Second, the particles form a reflective curtain along the equator side of the auroral zone for VHF auroral scatter propagation openings. Third, the F region of the ionosphere toward the equator from the auroral zone is depleted to form a trough where the maximum usable frequency (MUF) for a particular path through this area decreases by 30 to 50 percent. Paths through the trough require the lower frequency bands. However, north of the geomagnetic equator a similar-size enhancement of the F region MUF takes place to give the evening trans-equatorial openings during the equinox and winter seasons. These three effects are not steady but quite variable on any time scale (hours, minutes, or seconds); therefore fading is an almost normal occurrence. The effects continue to occur each night for 2 to 3 days before ionospheric equilibrium is obtained again. The bigger the geomagnetic storm (higher K or A value) the closer to the equator these effects occur.

You'll remember during the last spring equinoctial period, March, April, and into May, seven periods were experienced with these phenomena going on for days at a time. This was the most disturbed period so far this solar cycle. We may not have a fall equinox like the spring disturbances, but if so, you can be on the lookout for those effects. When the ionosphere is this variable, DX openings come at very odd times and locations with weak and fading signals. Be on the lookout for that needed country or just have a lot of fun.

gray-line DX

Another equinox propagation phenomena for interesting DX is known as gray-line DX. This propagation enhances DX on north-south paths over the polar regions during quiet geomagnetic conditions. The best times for openings are just as dawn or sunset comes upon your location with your antenna pointed north or south. Signals will be unbelievably strong and clear, reminiscent of sporadic E (Es) one hop. By the way, there may be a few short-skip openings from Es left for this summer's Es season, if you're lucky enough to catch them. Let's look at the September forecast.

The 27-day solar minimum is expected about the 13th of September, building to a maximum about the 27th. Geomagnetic disturbances from solar flares are expected as short periods during ascending activity around September 23 and even more likely on the descent about the 30th. A longer disturbance may be experienced about the 10th if a solar coronal hole develops near the minimum solar activity. Solar flux should be building somewhat into the winter months for better DX.

Full moon is on the 14th and perigee on the 17th this month. The time the equinox occurs is on September 23rd at 0305UT.

band-by-band summary

Six meters will provide some excellent openings to South Africa from the eastern U.S. and from the western and central U.S. to Australia and New Zealand around local noontime. The openings are more probable during high solar flux values.

Ten, fifteen, and twenty meters will be full of signals from morning into early evening almost every day and to most areas of the world. The openings will be shorter on the higher bands and concentrated more near noon for the path of interest. High solar flux values and geomagnetic disturbance will favor these bands for trans-equatorial contacts.

Forty, eighty, and one-sixty meters are the night DXer's bands. The bands are open beginning just before sunset and lasting until just as the sun comes up on the path of interest. Except for daytime short-skip signal strengths, high solar flux values don't affect these bands much. Geomagnetic disturbances may cause much signal attenuation and fading on polar paths.

*Look at next **higher** band for possible openings.

SEPTEMBER

GMT	PDT	WESTERN USA N	NE	E	SE	S	SW	W	NW
0000	5:00	10	—	10	15	—	10	10	10
0100	6:00	10	—	10	15	15	10	10	10
0200	7:00	10	—	15	15*	15	10	10	10
0300	8:00	10	—	15	15	15	10	10	15
0400	9:00	15	—	20	15	15	10	10	15
0500	10:00	20	—	20	20	20*	15	10	15
0600	11:00	20	—	20	20	20	15	10	20
0700	12:00	—	—	20	20	20	15	15	20
0800	1:00	—	—	20	20	20	20	15	20
0900	2:00	—	—	—	20	20	20	15	40*
1000	3:00	—	—	—	20	20	20	20	40*
1100	4:00	—	—	—	—	—	20	20	20
1200	5:00	—	—	—	—	—	20	20	20
1300	6:00	—	20	—	—	—	40	20	20
1400	7:00	20	20	—	—	—	40	—	40*
1500	8:00	20	15	10	10	20	20	20	20
1600	9:00	20	15*	10	10	20	—	20	20
1700	10:00	20	15*	10	10	15	—	20*	20
1800	11:00	15	15*	10	10	15	—	—	20
1900	12:00	15	15	10	10	15	10	—	—
2000	1:00	20	15	10	10	15	10	10	—
2100	2:00	—	20	10	10	15	10	10	10
2200	3:00	—	20	10	15	15	10	10	10
2300	4:00	—	20	10	15	15	10	10	10

MDT	MID USA N	NE	E	SE	S	SW	W	NW
6:00	10	20	15	10	—	10	10	10
7:00	10	—	20	15	15	10	10	10
8:00	10	—	20	15	15	10	10	15
9:00	15	—	20	20	15	15	15	15
10:00	15	—	20	20	20	15	15	15
11:00	20	20	20	20	20	15	20	20
12:00	20	20	20	20	20	20	20	20
1:00	20	—	20	20	20	20	20	20
2:00	20	—	20	20	20	20	20	20
3:00	—	—	20	20	20	20	20	20
4:00	—	—	—	40	20	20	20	20
5:00	—	20	—	40	—	20	20	20
6:00	—	20	—	—	—	20	20	—
7:00	20	15	—	—	—	20	—	—
8:00	20	15*	10	10	—	20	20	—
9:00	20	15*	10	10	—	20	20*	—
10:00	20	10	10	10	—	—	20*	—
11:00	15	15*	10	10	15	—	—	—
12:00	15	15*	10	10	15	10	—	—
1:00	20	15	10	10	15	10	—	—
2:00	—	15	10	10	15	10	10	—
3:00	—	15	10	10	15	10	10	10
4:00	—	20	15	10	15	10	10	10
5:00	—	20	15	10	15	10	10	10

CDT	EASTERN USA N	NE	E	SE	S	SW	W	NW
7:00	10	20	20	15	20	10	10	10
8:00	15	20	20	15	20	10	10	15
9:00	15	40	20	20	20	15	15	15
10:00	20	40	20	20	20	15	15	20
11:00	20	40	20	20	20	20	20	20
12:00	20	—	20*	20	20	20	20	20
1:00	—	—	20	20	20	20	20	20
2:00	—	—	20	20	20	20	20	20
3:00	—	—	20	20	20	20	20	20
4:00	—	20	—	20	20	20	20	—
5:00	—	20	—	20	—	20	—	—
6:00	20	15	—	20	—	—	—	—
7:00	20	15	10	20	—	—	—	—
8:00	20	10	10	20	—	20	15	—
9:00	15	10	10	10	—	—	15	—
10:00	15	10	10	10	20	—	15	—
11:00	15	10	10	10	20	—	20	—
12:00	15	10	10	10	15	—	20	—
1:00	15	15	10	10	15	—	20	—
2:00	—	15	10	10	15	10	10	—
3:00	—	20	10	10	15	10	10	—
4:00	—	20	15	10	15	10	10	10
5:00	10	20	15	10	15	10	10	10
6:00	10	20	15	15	15	10	10	10

	ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN
	ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN
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RFI cures:

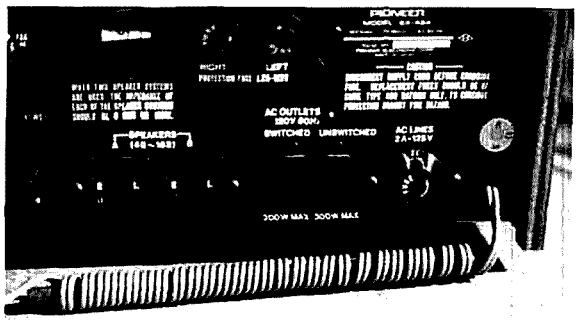
avoiding side effects

Advice on preventing additional problems when making RFI fixes to home-entertainment equipment

Many Amateurs have had it happen: You're on the air and the phone rings, or there's a loud knock on your door. It's a neighbor who says, "Your signals are getting into my stereo and clock radio." Whatever the device, you are expected to do something about it. The problem still exists today, despite advances in engineering. If you want to stay on the air and keep peace in the neighborhood, you might offer to add a few components to the affected equipment to make it less susceptible to RFI.

Much has been published in the Amateur literature on cures for Amateur-caused radio-frequency interference (RFI) to these devices. If you handle the problem diplomatically and apply the appropriate cure to your neighbor's equipment, the interference from your Amateur transmitter may disappear, but you may be faced with more problems. What happens when your neighbor's precious stereo set doesn't have the original audio response it had before you made the fix? Suppose your friendly neighbor's phono preamp develops a 60-Hz hum after you've added components to cure RFI?

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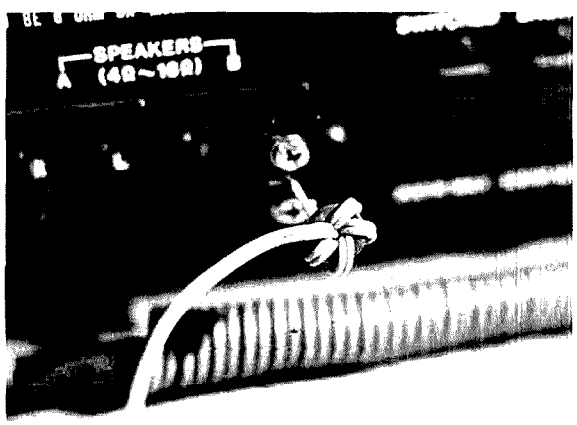


If the interference is entering the stereo through the ac line, the cord can be wrapped around a ferrite rod to form a bifilar choke.

This article is based on my experience with RFI problems in commercial home-entertainment devices. It offers some advice on dealing with the side effects that can occur when trying to tame such devices. Such side effects include parasitic oscillations and high-frequency attenuation in audio amplifiers, hum in phonograph preamps, and the so-called "hot-chassis" syndrome.

a personal experience

Not long ago, a neighbor and I were victims of RFI. After determining that the offending CB transceiver was being operated legally, we added the standard filtering and shielding to our stereos only to encounter the side effects of these commonly accepted RFI cures. The side effects included parasitic oscillations, high-frequency attenuation, the hot-chassis syndrome, and a 60-Hz hum. Since each of these side effects is the result of a different cure, each must be considered separately.



Parasitic oscillations and high-frequency attenuation (described in the text) can be avoided by installing a toroid on each speaker lead.

parasitic oscillations

Bypass capacitors on speaker leads are sometimes unnecessary and often their effect can be disastrous. Fortunately I didn't destroy the audio output transistors in my receiver. Another RFI victim in my neighborhood wasn't so lucky: capacitors on the speaker leads of his stereo set caused feedback, and the resulting high-frequency oscillations destroyed the audio power amplifier.

Some solid-state amplifiers will oscillate when bypass capacitors are placed across their output. Quite often, these oscillations occur at frequencies too high to be audible. These parasitic oscillations can cause overheating of the output transistors and put an extra burden on the power supply. The sad part is that often bypass capacitors aren't needed on the speaker leads. Many articles on RFI suppression recommend bypassing speaker leads for rf. But unless the leads are acting as an antenna, there's no need for this cure.

How can you tell if the speaker leads are acting as an antenna? If you're using a receiver with a headphone jack, disconnect all speakers at the receiver output, plug in a set of headphones, and listen. If the receiver doesn't have a headphone jack, disconnect all speakers at the receiver and connect headphones to the receiver output with short jumper wires. If the interference disappears when the speakers are disconnected, it's safe to assume that the speaker wires are acting as an antenna. If the interference remains, you'll need to keep looking and listening to find out how the offending signal is getting into the stereo set.

high-frequency attenuation

Another approach to keeping rf on the speaker leads from getting into the receiver is to use an rf choke in series with the speaker leads at the receiver (**fig. 1**). In theory this works fine; in reality it creates a new set of problems. The inductive reactance of the rf choke will prevent rf from reaching the receiver, but the choke will have enough reactance to attenuate higher audio frequencies as well.

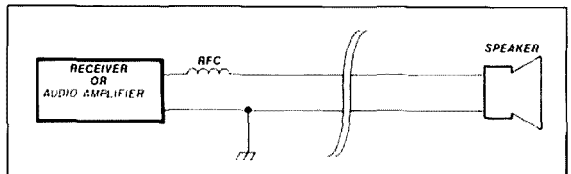


fig. 1. An rf choke in series with a speaker lead can cause high-frequency attentuation as described in the text. An alternative is to use a ferrite bead on each speaker lead or thread each lead through a toroid core.

For example: 2.5 mH at 15 kHz will have a reactance of approximately 235 ohms. At 500 Hz that same 2.5 mH will have a reactance of less than 8 ohms. The load on the receiver will be changing because the reactance of the choke will constantly be changing with frequency. A substantial amount of power will be lost in the choke. Most small, pi-wound chokes are designed for small amounts of current, generally 1 ampere or less. At higher audio frequencies, the reactance of the choke will limit current through the series combination of choke and speaker. But, at lower frequencies and higher power levels, the current through the choke could reach several amperes, until the choke overheats and acts like a fuse. Now the audio output stage is looking into an open circuit.

Some receivers and amplifiers can tolerate loads of varying impedance; others can't. An alternative to the rf choke is to slip a ferrite bead over the speaker lead at the receiver or, in more stubborn cases, thread the lead through a toroid core (see photo).

Another cause of high-frequency attenuation is excessive capacitance in the signal path. In my stereo, the CB signal was getting into the phono preamp through the magnetic phono cartridge. This problem was confirmed by removing the cartridge from the tone arm without hearing any interference.

The simplest approach to this problem was to add rf bypass capacitors to the phono preamp inputs. When 100-pF capacitors were installed, as shown in **fig. 2**, a noticeable deterioration occurred in the high-frequency response. The reason for the attenuation of high frequencies is that the total capacitance in the signal path exceeded the maximum load capacitance the cartridge could tolerate. **Fig. 3** illustrates the factors that contribute to the total capacitance in the circuit.

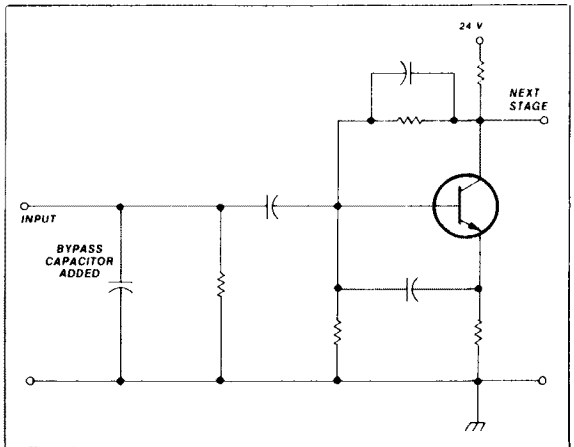


fig. 2. Unless the value of the bypass capacitor is chosen very carefully, high-frequency attenuation of the stereo's audio can result.

How much capacitance is too much? Specification sheets for good-quality phono cartridges include data for the optimum load resistance and maximum load capacitance. High-frequency attenuation can be avoided by keeping the total capacitance well below the maximum tolerable capacitance.

hum

Phono preamps are high-gain, high-impedance circuits. Adding any unshielded components to their inputs can result in an annoying hum. The side effect is the result of installing rf chokes in the preamp input circuits, as shown in **fig. 4**. Although rf chokes will solve the interference problem without causing high-frequency attenuation, any nearby magnetic fields will induce enough voltage in the choke to cause a 60-Hz hum. Depending on the intensity of the magnetic field and the type choke used, the hum could range from barely audible to loud and objectionable.

the hot chassis syndrome

Occasionally, rf will find its way into a stereo by way of the ac line cord. The commonly accepted cure for this type of RFI consists of placing bypass capacitors across the primary of the power transformer (**fig. 5**). While this will prevent rf from getting into the stereo through the ac line, it might create a shock hazard. This problem arises from the fact that almost all consumer audio equipment uses a two-wire line cord. The chassis is almost never at ground

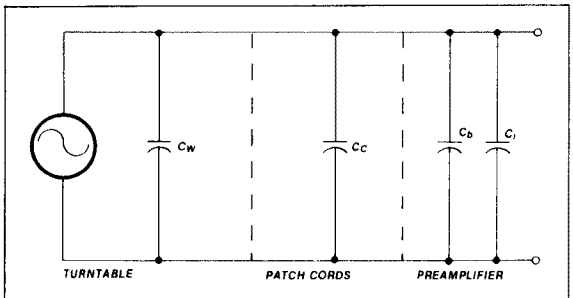


fig. 3. Total capacitance in the signal path will be the sum of the following: C_w, wiring in the tone arm; C_c, patch cords; C_b, the bypass capacitor; and C_i, the input capacitance of the preamplifier itself.

potential and, with the addition of the bypass capacitors, the potential between chassis and ground terminal of a three-wire outlet can be as much as 20 volts. (This number is based on my own measurements and may vary, depending on the type of equipment and the value of the bypass capacitors as well as other factors).

avoiding side effects

There's nothing mysterious about avoiding side effects of RFI cures. All it takes is a basic understanding of electronic theory and some common sense in application.

Parasitic oscillations can be avoided by not putting bypass capacitors on speaker leads unless it's absolutely necessary, and then only when recommended by the manufacturer of the equipment affected.

Since high-frequency attenuation can be caused by either of two cures, there are two ways to avoid

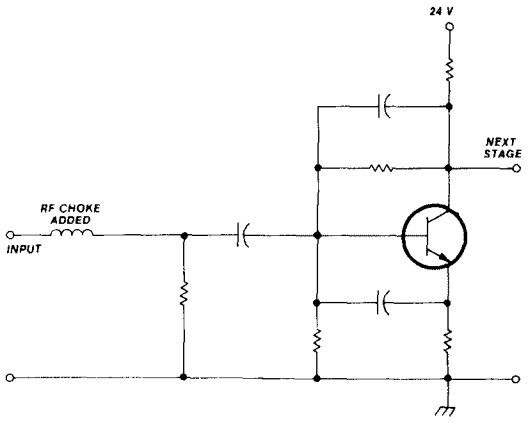


fig. 4. Adding an rf choke to the input of an amplifier may cure RFI but can cause hum in high-gain circuits.

such attenuation. If it's necessary to use rf chokes on the speaker leads, use the smallest amount of inductance that will do the job. If one or two ferrite beads placed on each speaker lead at the amplifier don't provide enough inductance, try a toroid, as shown in the photo.

When high-frequency attenuation is caused by too much capacitance in the signal path, the solution is to reduce the capacitance wherever possible. If a bypass capacitor is needed on each preamp input, use the smallest value that will cure the RFI problem. An old rule of thumb states that *the reactance of the bypass capacitor should be one tenth the impedance of the circuit being bypassed at the lowest frequency encountered.* If poorly shielded patch cords contribute to an RFI problem, replace them with RG-59 coax cable. Why use RG-59 when RG-58 is less expensive and more flexible? Answer: RG-59 cable has less capacitance per unit length.

Hum can be avoided by not adding unshielded components to high gain circuits. If an rf choke is needed on a preamp input to block out the offending signal, very carefully remove the first amplifying transistor from the circuit and slip a ferrite bead over the input lead.

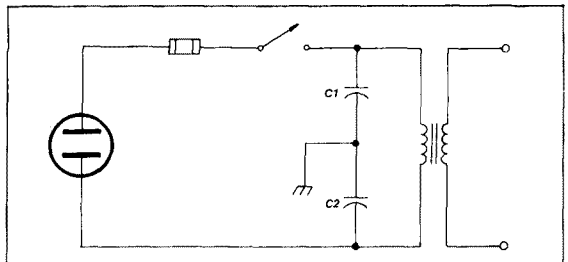


fig. 5. Capacitors *C1* and *C2* form a voltage divider, which places the chassis above ground for ac. A three-wire line cord might help.

If the rf is entering the receiver or amplifier on the ac line, the hot-chassis syndrome can be prevented by using a bifilar choke, as shown in the photo.

If wrapping the ac-line cord around a ferrite rod to form a bifilar choke is too bulky or inconvenient, the hot-chassis syndrome can still be avoided. When installing capacitors across the power-transformer primary winding, make sure the caps have a high-enough voltage rating to withstand the peak ac voltage plus any surges, spikes or transients that may occur. A 600-volt rating is usually adequate. Also make sure the capacitors have a very high leakage resistance. One final step you can take is to add a three-wire line cord. When the chassis is grounded through the line cord, a shorted capacitor will blow the fuse.

some final thoughts

Because of the variety of tuners, turntables, tape decks, preamps, power amplifiers, graphic equalizers, and speakers on the market, no two cases of RFI are exactly alike. Add to this the variety of antennas and transmitters available to the Amateur-Radio operator and very few sources of RFI are exactly alike.

The point is that one audiophile might suffer from interference and his neighbor might not. One audio amplifier might have an adverse reaction to a commonly accepted RFI cure, and another might not.

The intent of this article has been to make you aware of some of the common side effects of RFI cures and how they can be avoided. However, when in doubt consult the manufacturer! For example, if an audio amplifier uses inverse feedback to reduce distortion, the manufacturer can tell you if adding capacitors across the output will send it into a frenzy of oscillation.

I repeat! When in doubt, consult the manufacturer.

ham radio

the how and why of multiplexing

An interesting communications technique with practical suggestions for Amateur use

Those who have studied for an Amateur license know that radio signals are modulated to transmit intelligence. Such modulation may be thought of as one form of multiplexing — transmitting and receiving simultaneously two or more messages or signals over a common medium.

To consider modulation and multiplex systems, it's best to consider electromagnetic radiation in two different forms or domains. Engineers look at such signals in the time domain, as in a waveform displayed on an oscilloscope; and in the frequency domain, as in a signal displayed on a spectrum analyzer.

Fortunately, there's a convenient way to transform the information contained in one form to that contained in another. It is called the Fourier transform. Any college text on communications systems will have a description of the Fourier transform and its use. The complete derivation of such a transform is mathematically complex and difficult to handle. For the purposes of this article, we'll say that signals can be described in both time and frequency domains. **Fig. 1** shows a few examples of how signals look in these domains. The acronyms used in the article are defined at the end of this article.

There are a number of ways to modulate a carrier with intelligence. Before discussing multiplexing, let's look at the advantages and disadvantages of the different modulation types.

signal modulating systems

The simplest form of modulation suitable for voice transmission is amplitude modulation (a-m). This form of modulation is created by modulating the strength, or amplitude, of a carrier-frequency wave at an audio rate. The simplest case of a-m is shown in the modulated waveform of **fig. 1C**. Amplitude modulation has advantages and disadvantages. One advantage is in the simplicity of the receiver. This is why this form of modulation was used in the first commercial broadcasts and continues to be used today. Among the disadvantages are a waste of transmitter power and a signal-to-noise ratio that can be improved.

The term "signal-to-noise ratio" is used here to denote the quality of a communications system. All communications systems contain some amount of noise. With more signal and less noise, the signal-to-noise ratio increases. All modulation methods can be compared mathematically on the basis of the expected signal-to-noise ratio. In commercial applications, this comparison often determines what is suitable and what is not.

Double sideband. Other derivatives of the amplitude-modulation technique are used by Amateurs. Double-sideband, suppressed carrier, and single-sideband, suppressed carrier are forms based on amplitude modulation. They can, in fact, be created by filtering unwanted components from a normal a-m signal. Double-sideband, suppressed carrier has

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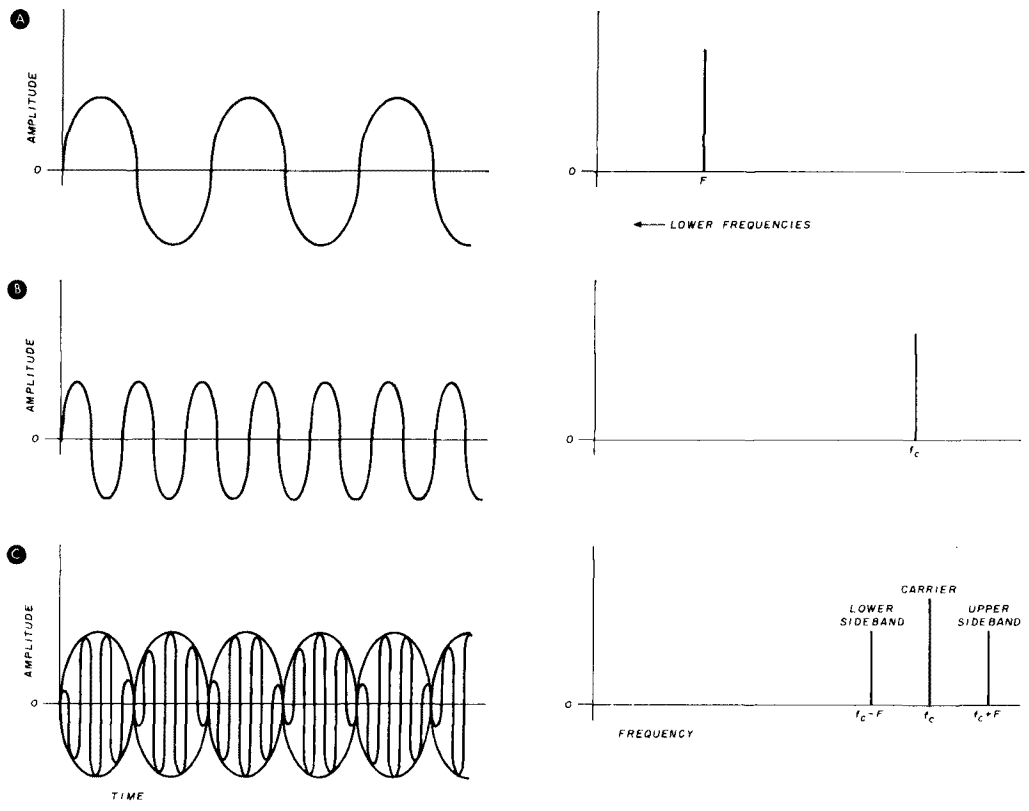


fig. 1. Examples of radio signals in terms of time and frequency domains. In (A), left, a modulating frequency (sine wave) is shown as it would be displayed on an oscilloscope in the time domain. The same signal is shown at right as it would be displayed on a spectrum analyzer in the frequency domain. Drawing (B) shows a carrier signal (also a sine wave) in the time domain (left) and the same signal in the frequency domain (right). A 100-percent a-m carrier, modulated by a single tone of frequency F, is depicted in (C) in the time domain (left) and in the frequency domain (right). F is modulation frequency; f_c is carrier frequency.

the advantage of transmitting information on the signal and eliminating wasted power created by transmitting the carrier signal. It does, however, duplicate the transmission of the information signal by transmitting the same information in both sidebands.

Single-sideband. Single-sideband, suppressed carrier transmission provides some of the most efficient use of the radio spectrum. The intelligence is not transmitted in duplicate, and the power used in transmitting the carrier in other modulation systems is used instead for intelligence.

There is one disadvantage, however. Single-sideband, suppressed carrier provides no reference signal for the receiver to determine accurately the signal center frequency. In many control and signalling applications, this is a serious shortcoming. Without accurate frequency control, for example, Touch-Tone™* signalling is not possible. In Amateur high-frequency applications, the advantages of this mode far outweigh the disadvantages. Operators become accustomed to the sound of single sideband and can eventually understand the signal, even when tuned off frequency.

In critical commercial and military applications, this problem is overcome in a different way. Cesium frequency standards with exceptional accuracy and stability control both transmitter and receiver.

Frequency modulation. Another of the most common modulation forms is fm. It is formed by varying the instantaneous frequency of the transmitted signal at an audio rate (or more precisely, at an intelligence rate). The frequency of the modulating signal

*Touch-Tone is a registered trademark of The American Telephone and Telegraph Company.

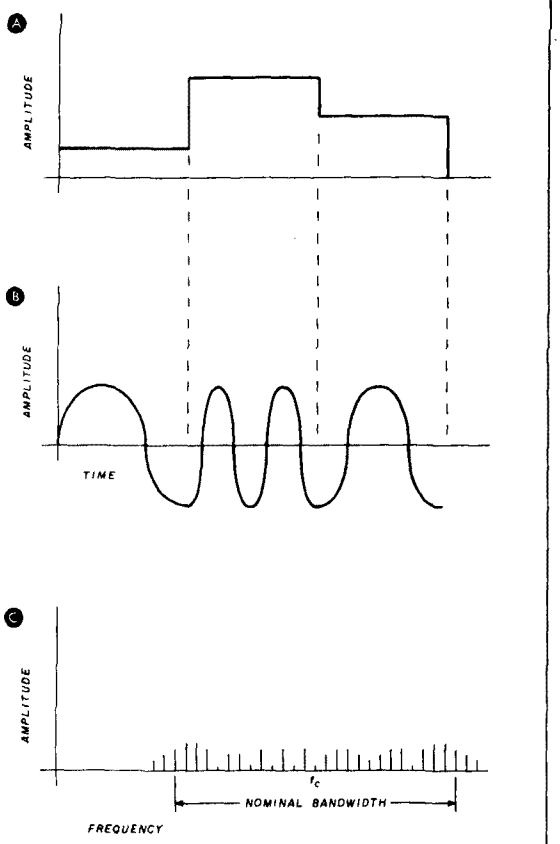


fig. 2. A comparison of an fm signal in the time domain (top two drawings) and in the frequency domain (bottom drawing). The modulating signal is depicted in (A), with the resultant transmitted signal shown in (B). The same signal and its nominal bandwidth, which is a function of deviation, is shown in (C).

is determined by how many excursions across the center frequency are made in a given period. The amplitude of the modulating signal is determined by the amount of actual frequency change. A wider frequency excursion is indicative of a higher modulating amplitude. The comparison of an fm signal in the time and frequency domains is more complex than that of an a-m signal (**fig. 2**).

Frequency modulation can take on different characteristics depending upon the width of the signal, or deviation.* When the signal is modulated to produce a signal approximately the same width as a standard *double-sideband a-m signal, it* provides a signal-to-noise ratio equal to that of an a-m signal. This is the case with the modulation used on 2-meter fm.

It does have some advantages over a-m, however. One of the advantages is that fm can be amplified by a class-C amplifier. On first inspection this may not seem to be such a tremendous advantage. There are cases, however, where it's either impossible or impractical to create a good class-A or class-B amplifier. It's much easier in most cases, for example, to operate a microwave system with fm rather than a-m. In the past, it was not possible to produce and amplify an a-m signal at these frequencies.

Fm exhibits a very interesting threshold effect. In the reception of fm, once the signal level has increased beyond a particular level, there is no significant improvement in signal-to-noise ratio that can be obtained by an increase in power. This effect can be used to advantage in an fm system.

Where fm really comes into its own is in wide-band applications. An improvement in signal-to-noise ratio

*That is, the excursion of the modulated signal in the frequency domain. **Editor**

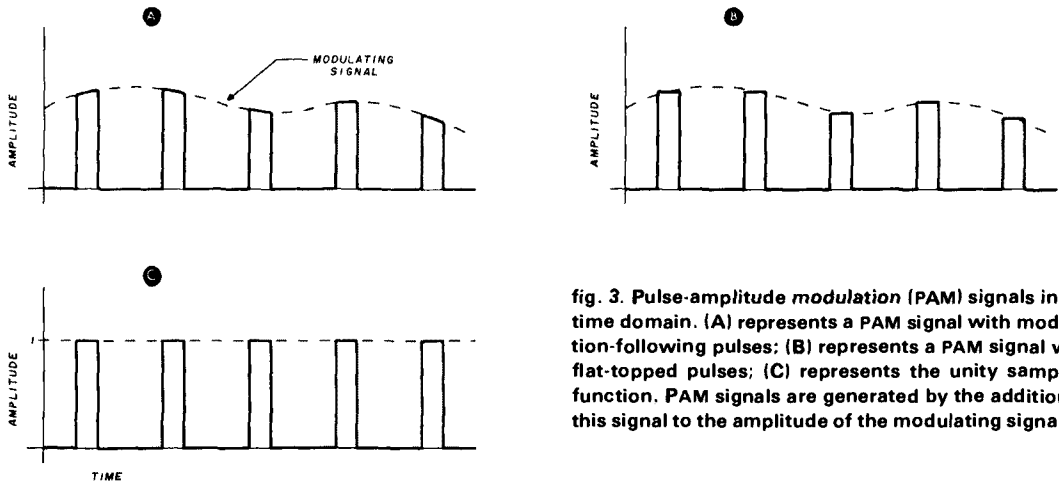


fig. 3. Pulse-amplitude *modulation* (PAM) signals in the time domain. (A) represents a PAM signal with modulation-following pulses; (B) represents a PAM signal with flat-topped pulses; (C) represents the unity sampling function. PAM signals are generated by the addition of this signal to the amplitude of the modulating signal.

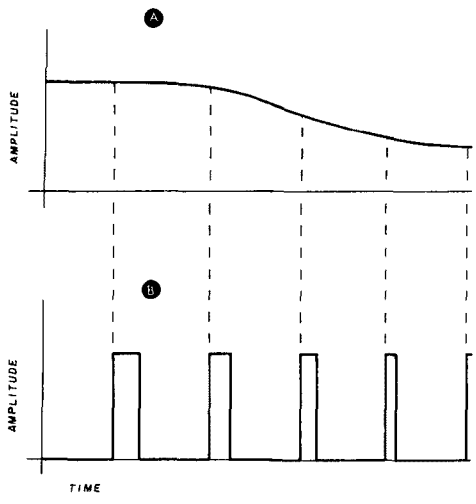


fig. 4. Example of pulse-duration modulation (PDM). The amplitude of the modulation signal controls the width of the transmitted pulse. The modulating waveform is represented in (A); the PDM waveform in (B).

can be achieved at a sacrifice of bandwidth. For many years this phenomenon was not appreciated. After all, it doesn't make sense that a wider bandwidth, which allows more noise energy to enter the system, would allow better reception. There are a couple of ways to implement this effect, and it usually involves detectors in the receiver that apply frequency-compression feedback. In this process, the receiver i-f bandwidth is made to look narrower than the transmitted signal. Many critical commercial applications make use of this method when the spectrum bandwidth is available.

digital-modulation methods

Some of the greatest technical strides have recently been made in digital modulation techniques. There are a number of different methods:

Pulse-amplitude modulation. This form of modulation, as in all digital methods, relies upon a principle called sampling. The sampling theorem states that, if the information signal is sampled at a fast enough rate, the signal can be reconstructed on the basis of the sample values. This is further refined in the Nyquist theorem, which states that the minimum frequency at which the samples may be taken is twice the frequency of the highest frequency component in the information signal.

The samples may be thought of as having been taken instantaneously and transmitted in the same way. This, then, provides the amplitude of the information waveform at discrete intervals of time. In pulse-amplitude modulation, this information is used to determine the amplitude of the transmitted pulse, as the name implies. This modulation method is shown in **fig. 3**. Note that the pulses can be modulated as flat-topped pulses (**fig. 3B**) or following the signal waveform during its period of transmission (**fig. 3A**). If the pulses are transmitted sufficiently fast that time is still available between them, the possibility exists to put other information in the spaces. (We will examine this in more detail a little later.) PAM is one of the easiest forms of digital modulation to recover, since a lowpass filter will recover the original modulating waveform. In fact, most forms of digital modulation are converted back into PAM in the demodulation process to recover the signals.

Pulse-duration modulation. The next modulation form we will consider is pulse-duration modulation (PDM). In this method, the amplitude of the modulating signal controls the width of the transmitted pulse. An example is shown in **fig. 4**. The simplest way to generate the pulses is to allow a time-constant circuit to charge or discharge to the modulating signal amplitude and allow the duration of this process to control the pulse length. In the demodulation-process, as stated above, the PDM signal is usually converted into a PAM signal, then demodulated as a PAM signal.

The PDM signal has a very interesting advantage. The receiver must make a relatively simple decision — is the pulse there or is it not? This can be compli-

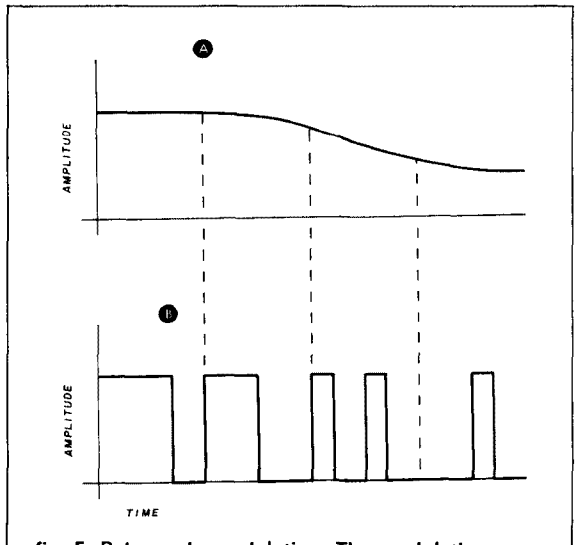


fig. 5. Pulse-code modulation. The modulation waveform, (A), results from the digital representation of the signal, (B).

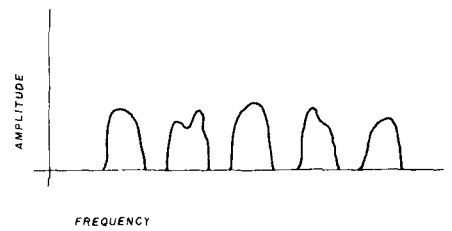


fig. 6. Example of frequency-division multiplexing (FDM) depicted in the frequency domain. Individual SSB signals are combined and transmitted by one transmitter. An example might be an OSCAR downlink.

cated by noise; but in general, it allows for improvement of the signal-to-noise ratio in otherwise marginal conditions. The received signal can be hard-limited, removing all amplitude information, to overcome a fairly large amount of amplitude variation or QSB.

Pulse-code modulation. Another form of digital modulation is pulse-code modulation (PCM). It is produced by transmitting some digital representation of the signal rather than the signal itself (**fig. 5**). For example, the binary-coded decimal value of the voltage at the time of the sampling could be transmitted directly. This would result in the transmission of a series of pulses for each sample rather than the single transmitted pulse for each sample as in PAM and PDM. PCM has the advantage, shown by PDM, in that the detector must make the simple decision of whether the pulse was, or was not, transmitted.

Other interesting properties may also be used in PCM. The transmitted code can be specially formulated to improve the signal-to-noise response of the system. In this way, the code predicts what a typical noise burst would do to the received signal and attempts to provide a received signal that will allow less ambiguity. This system is presently the subject of much interest and research in commercial and military areas.

Well, this has been a fairly rough overview of most of the modulation systems. All can and are used in multiplexing. So what is this multiplexing, anyway?

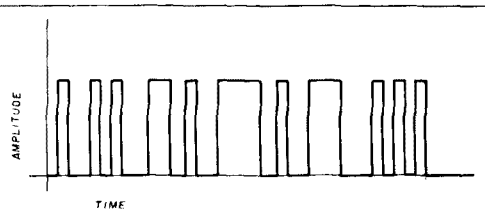


fig. 7. One time-division multiplex (TDM) interval or *frame*, which combines digital signals of different types and data rates.

multiplexing

The dictionary defines multiplex as "...a system for transmitting or receiving simultaneously two or more messages or signals over a common circuit, carrier wave, etc." Amateur Radio operators, in general, don't know too much about this technology. In general, we don't have much need for it. Most Amateur communications are conducted on one simplex circuit with no need for simultaneous transmission. Let's look at some ways we can make use of multiplex systems.

In commercial and military communications areas, multiplex is a necessity. These users are concerned with the transmission of many messages at the same time. Imagine the expense it would require to use a separate radio for each telephone conversation! Many different multiplex methods are used to accomplish this requirement.

We've seen that signals can be represented in both the frequency and time domains; this suggests two ways to multiplex signals. In fact, methods are used in which signals are multiplexed in both time and frequency. First let's look at methods of multiplexing signals in the frequency domain.

One method involves the placement of many different signals side-by-side in frequency in the transmitted signal — called frequency-division multiplex, or FDM. A way of looking at this is to consider a number of fm signals being transmitted in a given band. All these signals could be transmitted by a single transmitter rather than the many signals required for single-signal transmission.

The individual information signals could also be modulated by amplitude-modulation-based techniques. This could use single-sideband modulation to reduce the spectrum space required by the signals. In this way the transmitter of the OSCAR satellites could be thought of as a multiplex system. All of the input signals are combined and transmitted by one transmitter on the downlink side. **Fig. 6** shows how the transmitted signal might look in the frequency domain with separate single-sideband signals multiplexed.

There is another form of frequency multiplexing — the frequency modulation of the main carrier with frequency-modulated subcarriers. The representation of the final modulated signal is much more complex than that of normal FDM as shown in **fig. 6**. This is due to the rather complex nature of the display of fm in the frequency domain, as shown in **fig. 2**. This is the most common of multiplex systems used in common-carrier microwave systems, as we shall see later. It can be referred to as fm-fm.

Digital-modulation types offer relatively simple

multiplexing in the time domain. Taking another look at **figs. 3, 4,** and **5** we see that there is space between the transmitted pulses in each case. If the pulses are transmitted in a short enough period of time, there is enough room to insert many additional signals. This is called time-division multiplex, or TDM. All this requires is that each individual signal be sampled (and the sample transmitted) faster than the Nyquist rate (discussed previously). The samples can be transmitted as they are taken, or they can be stored to be transmitted at an appropriate time.

Any of the digital modulation types can be used in TDM. All that is required of them is that they be separated from the other signals in the time domain at the receive demultiplexer. In fact, digital signals of different types and different data rates can be combined in one TDM signal. The entire combination of signals transmitted in one interval is called a frame. An example of a TDM frame is shown in **fig. 7**. Often a group of signals can be combined into a TDM frame before they are combined with another similar group for the final transmitted frame. This can be referred to as low-speed and high-speed TDM. The low-speed TDM frames are combined to be transmitted as one high-speed TDM frame.

commercial multiplex applications

Now that we know what multiplex is, what are some of the commercial applications? Broadcast television can be thought of as a form of FDM. The video and audio information is transmitted by the same transmitter using separate carriers for the two signals. In this particular case, the audio is transmitted using fm and the video with a form of a-m — vestigial sideband amplitude modulation. In vestigial sideband, one of the sidebands is suppressed beyond a certain cutoff frequency but the carrier is transmitted at full power.

Broadcast fm stereo (often called fm multiplex) uses another special form of multiplex technique. In this type of signal, the main frequency-modulated signal carries the information for the left plus the right channels. A monophonic receiver detects only this signal. A double-sideband, suppressed-carrier signal transmitted with the fm signal carries the left minus the right channel information. The stereo receiver detects this signal, then algebraically subtracts it from the fm signal to produce the right and left channel information.

Another form of multiplex with commercial applications is voice frequency carrier telegraph, or VFCT. In this system a group of FSK (frequency shift keying) signals are combined in a form of FDM. The individual FSK signals are produced by shifting them over a narrow range of frequencies in the audio range. The resultant signals are then combined and transmitted with a single transmitter. The most common use of this system is in the simultaneous transmission of a group of teletypewriter signals. Different standards exist for the number of channels and the audio frequencies used, based upon the speed and necessary quantity of individual circuits.

In an earlier paragraph I made reference to an fm-fm system. This is the most common type of multiplex used in normal microwave circuits. In this method individual circuits are combined into groups. The groups are then combined into supergroups, and the supergroups are combined into a mastergroup. The normal commercial standard calls for twelve channels to be combined to form one group. Five groups are combined into one supergroup. Eleven supergroups are then combined into one mastergroup. This produces a link that will support 660 circuits (or channels) on one mastergroup. Mastergroups can then be combined to form multimastergroups. One commercial standard calls for the combination of six such mastergroups.

It can be seen that the resultant signal that is finally transmitted will be quite complex. It requires extensive frequency modulation detection, and the modulation for any given channel is effectively distributed across the entire transmitted spectrum. This system was the standard for many years because of the relative ease of modulating a tube microwave system with fm signals. In later years TDM techniques have proven more desirable.

With the advent of low-cost digital integrated circuits, TDM systems have been able to demonstrate distinct advantages at an over-all reduction in price over analog techniques. Standards have been developed to modulate the audio signals from a telephone and process them through the complete telephone exchange and send them out on long-distance microwave links, still in digital form.

One form of TDM gaining wide commercial acceptance calls for the combination of a group of audio signals, reduced to PCM data streams, onto a single PCM signal at a rate of 1.544 megabits per second (1.544×10^6 binary digits per second). These signals can then be further combined into larger PCM systems before transmission.

Commercial systems are also being created to handle digital information; that is, information which is already in digital form, using PCM networks. This technique is ideal for computer or teleprinter traffic. Systems have been demonstrated that allow signals of various data rates to be supported by a common system. The possible uses of such a system are limited only by the imagination of the users.

Amateur applications

Now that we have seen the different multiplex sys-

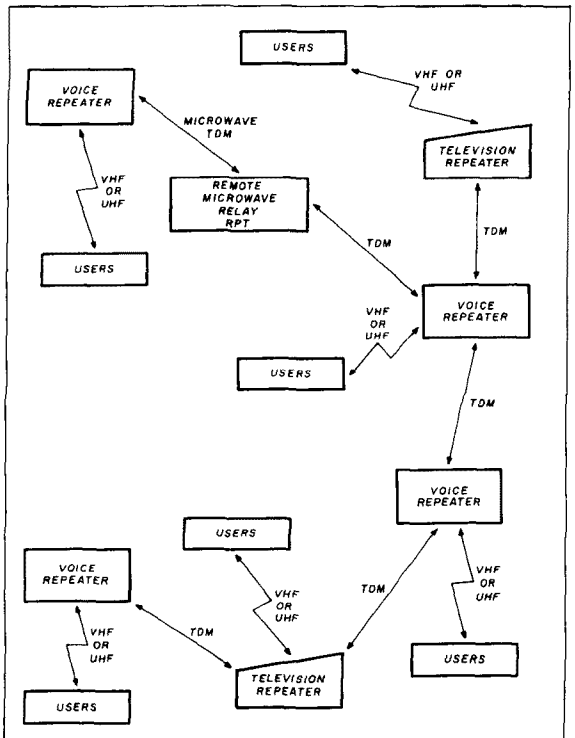


fig. 8. Suggested repeater interconnection network using time-division multiplex.

tems and how they are being used commercially, how can we as hams make use of them? Many possible applications are with us now, and many more are just a short time away.

Traffic nets. Let's look at the possible applications in the Amateur traffic nets. For years the Navy has used a form of high-frequency radioteletype broadcast. In this system the traffic for a whole group of ships is transmitted over a common VFCT. This VFCT multiplex group is even relayed to various points and retransmitted in its entirety to enable reception over a larger area. In this way, Amateur traffic for a large area could be transmitted over one VFCT system. Individual channels could be designated for certain sub-areas or for a particular net handling a certain type of traffic. Confirmations could be received over a different frequency in duplex fashion, and channels could be designated as reroute channels for traffic that was earlier transmitted and not confirmed. With a network of such VFCTs, the different traffic areas could be interconnected. In the long run, a computer could be used to receive the messages on individual circuits then combine them into the VFCT and wait for confirmations. It would determine either independently or with manual direction which route to send the message.

Repeater links. Another possible Amateur application is the interconnection of a group of repeaters. In this system users could select, through a remote-control system, which of the repeaters would be interconnected. A multiplex link could be provided from each of the repeaters in the group to each of the others. The control system would then decide which of the multiplex channels to interconnect. The multiplex system itself could use either the FDM or TDM techniques described above.

Now we can examine some firm proposals for such a repeater interconnecting multiplex system. TDM systems are taking over as the preferred method in the commercial field and would probably be best for us to use as well. TDM has some very real advantages for our uses. Foremost is its capability to support various data rates in one TDM system. This would allow normal voice repeaters to be connected to other similar repeaters in the system as well as provide separate channels for signaling applications. These signaling channels could use much lower data rates than those required for voice yet provide superior interconnecting control reliability. The same TDM system could also support interconnections of RTTY repeaters. Many RTTY channels could be placed in the same space as that required for one voice channel. In the long run, the same TDM system could support television repeaters. The video and audio signals could be digitized and transmitted as just another TDM component.

Hardware and bandwidth considerations. TDM equipment from commercial manufacturers is presently quite expensive, and few or no surplus sources exist. Fortunately, though, the equipment is fairly easy for Amateurs to construct to their specifications. The primary ingredients are digital integrated

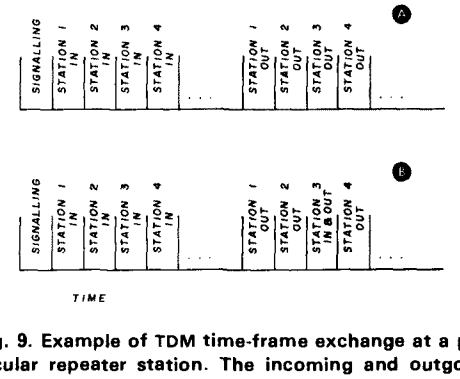


fig. 9. Example of TDM time-frame exchange at a particular repeater station. The incoming and outgoing TDM time frames at Station 3 are depicted in (A) and (B) respectively.

circuits, which are not all that expensive. Also, their use is fairly well understood by many Amateurs. About the only disadvantage to the use of TDM is the need to place the TDM signal on an Amateur frequency where pulse transmission is permitted. In general, the spectrum bandwidth necessary to transmit the digital representation of speech is wider than that required to transmit a normal amplitude-modulation representation.

Fig. 8 shows how some of these repeaters could be interconnected. This is just an example of the way the interconnection would be made. Many more repeaters of all types could be provided, rather than the limited number shown. Let's consider how this would be put in use to provide interconnections for twenty repeaters all along the West Coast.

Suggested repeater interconnection system. Each repeater would have the primary capacity of operating as an independent repeater — just as an existing repeater would do now whether the modulation is audio, RTTY, or television. In addition to this capability, each repeater would have a microwave radio transmitter and receiver, which would provide a link to the TDM interconnection. The microwave equipment would transmit all the TDM channels just as they had been received except for a) one channel designated as the incoming channel, and b) one channel designated as the outgoing channel for that particular repeater. On those channels, the multiplex equipment would demodulate the incoming signal and modulate the outgoing one. This in itself would be a tremendous advantage over FDM systems.

In FDM systems, a separate modulator system would be required for each channel, when in fact only one channel would be used at a particular time. This requirement exists because the individual channel modulators would have to be tuned to the subcarrier to be used. It would be very difficult to have the system function with a single modulator that would be somehow made to retune to the desired channel. In a TDM system, all that is required is that the system wait for another period of time before extracting or inserting the desired channel information from the TDM frame. A single-channel TDM multiplexer and demultiplexer would be all that the station required. As an alternative, a second channel could also be used for signaling, both incoming and outgoing. This channel would be shared by all the stations and be a common signaling channel. **Fig. 9** shows an example of the TDM frame received and transmitted at a particular station.

Note that in **fig. 9** the only real change in the frame is the contents of the TDM channel designated for Station 3 out. Station 3 combines the signal coming into the station on the Station 3 in channel with the normal output of the repeater. In this method, all the switching is done at the station originating the interconnection. Let's look at how this action would be performed.

Operation. To initiate the process, a user would call in to the repeater connected to the system that would be most easily accessed. Upon hearing no traffic on the repeater, the user would initiate the control sequence requesting the interconnection. This could consist of Touch-Tone™ digits for the address of the repeater requested. A TDM system at the repeater used by the caller would then select the channel from the TDM frame that carried the information for the requested repeater's output channel. This would be connected to the normal downlink transmitter from the originating repeater. The system would also transmit a short tone on the downlink from the repeater to indicate that the interconnection had been made. It would then connect the input signal from the user to the originating repeater to the in channel on the TDM frame for the requested repeater. When traffic is heard on the requested repeater, the user could make the call. Or, the user could just listen to the distant repeater and make no call — just wait for his party to show up.

Other uses. In the long run the system could be standardized, and even the frequencies of the repeaters themselves could be reused. This would allow a user with a small crystal-controlled handheld radio to access the system from many of the repeater locations and communicate through the entire system.

The uses of such a repeater interconnection are again limited only by our own imagination. It would be possible to interconnect many different types of repeaters with the same TDM network, as shown in **fig. 8**. A repeater that had become a part of the system (and had a microwave TDM system with a radio relay) could decide not to participate for some reason. All that would be necessary to remain out of the interconnection net would be to block the output TDM channel from that station.

The system could also be used to provide a very wide area of autopatch access for participating stations. This could be of tremendous value in remote areas during disasters. When normal commercial telephone communications are lost in an area, the interconnection system could be used to access an autopatch at any of the participating repeaters.

In the Amateur traffic area, such a system could have great value. The system could support data to many different points at very different data rates in an automated teleprinter traffic environment. Particular nodal stations could guard a given TDM channel and relay the traffic into other traffic nets, either with



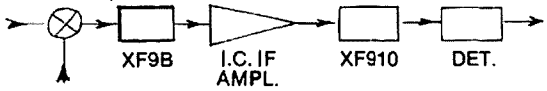
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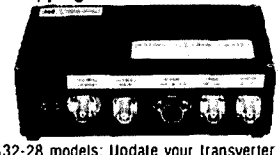
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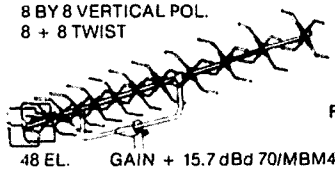
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high-frequency radio or VHF into repeaters within range of the nodal station. A high-volume nodal station may be assigned a 1200-baud circuit, with a single 75-baud circuit assigned to a station with relatively light traffic loads. Dedicated channels could be used to transmit traffic to a nodal station through various other transmission media.

With all the advantages such a system could provide, there are many other factors that would indicate that now is the time for the Amateur community to begin operations. The technology is now available to construct a TDM system with relative ease. Problems that had proven just too costly to deal with in the past have been overcome with integrated circuits. Such a TDM system is well within the realm of Amateur construction.

The Federal Communications Commission has recently taken very permissive views toward regulation. Many of the restrictions that had previously eliminated repeater interconnections have been done away with. It remains up to us to put the system in operation and work out any technical details — after all, that is one of the goals of Amateur Radio. The opportunity exists for us to demonstrate the capability of such a system for commercial use. So what are we waiting for?

As in all modes, the increased communications possibilities open questions of how to use them, which will have to be worked out by the using groups — political problems. The basic philosophy of how the system will be used will have to be determined. Some groups will welcome wide use by visitors, for instance, while others will wish to receive the benefits of their investment themselves. This is nothing new to us. It just provides many more possibilities for increased technical capabilities and increased public service.

glossary of terms

PAM	pulse-amplitude modulation
PDM	pulse-duration modulation
PCM	pulse-code modulation
FDM	frequency-division multiplex
TDM	time-division multiplex
VFCT	voice-frequency carrier telegraph

bibliography

Carlson, A. Bruce, *Communication Systems*, McGraw-Hill Book Co., 1968.

Taub, Herbert and Schilling, Donald L., *Principles of Communications Systems*. McGraw-Hill Book Co., 1971.

Reference Data for Radio Engineers, Howard W. Sams & Co., Sixth Edition, 1977.

Many other college-level textbooks are available containing detailed descriptions of multiplex techniques.

ham radio

Questions and Answers

Entries must be by letter or postcard only. No telephone requests will be accepted. All entries will be acknowledged when received. Those judged to be most informative to the most Amateurs will be published. Questions must relate to Amateur Radio.

Readers are invited to send a card with the question they feel is most useful that appears in each issue. Each month's winner will receive a prize. We will give a prize for the most popular question of the year. In the case of two or more questions on the same subject, the one arriving the earliest will be used.

radio waves

How fast does a radio wave travel, at the speed of light or slower? — Eugene Gabry, WB9VTF.

The velocity of a radio wave depends on the dielectric constant of the medium through which the wave travels. Air has a dielectric constant of unity, and radio waves travel through this medium at a speed very near to that of light in a vacuum, which is approximately 186,000 miles per second (3×10^8 meters per second).

In a medium that has a dielectric constant greater than unity, the radio wave travels at a lower velocity. For example, coaxial transmission line using polyethylene foam insulation has a dielectric constant of about 1.08, so radio waves propagate through this coax at something less than the speed of light through a vacuum. Thus when determining the electrical length of a transmission line, the velocity of propagation of the radio wave through the line, as well as other factors, must be taken into account.

FCC rules

I would like a correct interpretation of the FCC rules concerning third-party traffic. — Ralph R. Schlick, NØBOQ.

As of this writing, the FCC rules pertaining to third-party traffic consist of section 97.79, "Control Operator Requirements," and section 97.114, "Third-Party Traffic."

Section 97.79 states:

"The licensee of an amateur radio station may permit any third party to participate in amateur radio communication from his station, provided that a control operator is present and continuously monitors and supervises the radio communication to insure compliance with the rules."

Section 97.114 states:

"The transmission or delivery of the following amateur radiocommunication is prohibited.

"(a) International third party traffic except with countries which have assented thereto."

"(b) Third-party traffic involving material compensation, either tangible or intangible, direct or indirect, to a third party, a station licensee, a control operator, or any other person."

The FCC has proposed a revision of all the rules governing the Amateur Radio service, including those quoted above, in an effort to make them more understandable. Called the "plain-language" revision (Docket 80-729), the new rules might well become effective in the foreseeable future.

Reading the sections regarding third-party traffic in the existing rules, it is easy to understand how they could be confusing. In its new, "plain-language" revision, the FCC has attempted to define "third-party messages" and has simplified the existing rules. They have also added information on transmitting one-way communications for third parties, the reason being that one-way communications do not meet the existing definition of third-party messages. Other changes have been made to make the proposed rule consistent with Article 41 of the ITU rules, which refers only to the transmission of third-party communications being prohibited.

It's hoped that the new "plain language" rules will be easier to interpret. We'll just have to wait and see.

SWR meter

Is there any way to troubleshoot a defective SWR meter without a manual? I knew the instrument was defective after having placed a second meter that I know was OK in the line. The meter was made in Japan and the only name on it is "MARS Standing Wave Indicator SW-10." — Lewis I. Hegyi, N2BPO.

Without knowing anything about your meter, I find it difficult to offer any definite advice. If it is an inexpensive reflectometer, it probably contains a bridge circuit and a meter to indicate when bridge balance has been achieved. Most are not calibrated and therefore cannot be used to measure actual standing-wave ratio. Such instruments are generally used in conjunction with matching networks to indicate minimum reflected voltage or power.

Assuming there is no mechanical damage of components, you can make some simple tests to determine if the bridge elements are defective, either by substitution or by measuring resistance and capacitance. The resistors making up the bridge arms should be equally matched to obtain a good null on the meter. It's possible that the meter movement is burned out, as these simple reflectometers are usually designed to be operated at very low power. **ham radio**

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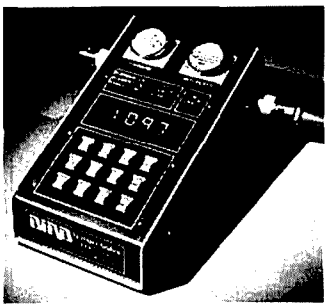
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ACTIVITIES

"Places to go..."

ALABAMA: The Calhoun County Amateur Radio Association's second annual Hamfest, Saturday, September 26, 9 AM to 5 PM, and Sunday, September 27, 9 AM to 3 PM, Municipal Auditorium, 1128 Gurnee Avenue, Anniston. Admission and parking free. Donations: $1 for one, $5 for 6. Tables $3 one day; $5 two days. Free overnight parking available for self-contained RVs. Air-conditioned exhibits, free bingo, hourly door prizes and more. Sunday drawing: Ten-Tec Delta 580. Talk-in on 69/09. Reduced rates and hospitality room Saturday evening at Anniston Downtowner Motor Inn. Information: Dale Boothe, KA4LRL, c/o CCARA, P.O. Box 1624, Anniston, AL 36202.

CALIFORNIA: The Golden Empire Flying Club jointly with Radio Systems Technology, announces the annual Fly-In and Avionics Swap Meet, Sunday, September 27, Nevada County (CA) Airpark. Swap Meet free. Table space limited.

COLORADO: The Boulder Amateur Radio Club's BARCFEST/81, Sunday, September 27, 9 AM, Boulder National Guard Armory, 4750 North Broadway, Boulder city limits. Donation: $2.00 per family includes swap space and door prize drawing. There will be a snack bar and auction. Talk-in on 146.10/70 and 146.52. For further information: Mark Call, N0MC, 4297 Redwood Ct., Boulder, CO 80301. (303) 442-2616.

FLORIDA: The Florida Gulf Coast Amateur Radio Council's "Suncoast Convention" (formerly Clearwater Convention), October 3 and 4, Sheraton Sand Key Hotel (same location as 1979). For information: Florida Gulf Coast Amateur Radio Council, Inc., P.O. Box 157, Clearwater, FL 33517.

GEORGIA: Augusta Amateur Radio Club's annual Hamfest will be held September 20, 1981, at the Julian Smith Casino. Prizes will be a DenTron Clipperton L, a Cushcraft A4 Tribander, and an Icom IC2A. Bingo for the family. Talk-in 34-94. Tailgating $3.00 includes one ticket. Tickets $1.00 each. Further information call Diane, WB4YHT, (404) 860-3700.

GEORGIA: The 8th annual Lanierland ARC Hamfest, September 27, 9 AM, Gainesville, Holiday Hall at Holiday Inn. Free tables, inside display area for dealers and distributors. Flea Market. Boat anchor auction. Prizes, activities. Doors open 8 AM for dealer set-up. Activities and facilities free. Prize tickets $1.00 each, 6/$5.00. Talk-in on 146.07/.67. For information: Paul Watkins, W4FDK, Rt. 11, Box 536, Gainesville, GA 30501. (404) 536-8280.

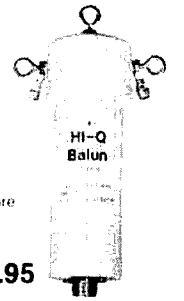
ILLINOIS: The Sangamon Valley Radio Club of Springfield's Sixth annual Hamfest, Sunday, September 27, Sangamon County Fairgrounds, New Berlin. Flea Market, exhibits, kids' activities, food available. Overnight camping. Tickets: $2.00 advance, $2.50 gate. First prize: ICOM Synth. HT. For information: S.V.R.C., c/o Red Cross Bldg., 1025 S. Sixth St., Springfield, IL 62703.

INDIANA: The Marshall County Amateur Radio Club's 8th annual Hamfest and Electronic Flea Market, Sunday, September 20, 4-H Fairgrounds, Argos. Tickets: $2.00 advance; $2.50 door. Door prizes, refreshments. Grand Prize $200.00. Hourly drawings. Dealers 6 AM, public 8 AM to 4 PM. Talk-in 146.52, 146.07 - 146.67 and 222.9 - 224.5. For information: Paul R. DeVos, WB9VFJ, 109 Maple Avenue, North Liberty, IN 46554. (219) 656-4631.

IOWA: The Cedar Valley Amateur Radio Club's 7th annual Hamfest, Sunday, September 27, Hawkeye Downs Exhibition Building, Cedar Rapids. Tickets: $2.00 advance, $3.00 door. Prizes: Kenwood, ICOM, Collins and more. Overnight camping area. ARRL representatives, movies. Talk-in 146.16-.76, .52, 223.34-.94. For tickets, reservations: CVARC Hamfest, P.O. Box 994, Cedar Rapids, IA 52406.

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- End or center insulators for antennas
- Construction of antenna loading coils or multiband traps

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D 40	40, 15	66'	79.95	76.95
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D 15	15	22'	69.95	64.95
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SD 80	80, 75	66'	77.95	73.95
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Parallel dipoles				
PD 80/40	80-40-20-15-10	130'	89.95	84.95
PD 40/20	40-20-15-10	66'	84.95	79.95
PD 80/40	80-40-15	130'	87.95	82.95
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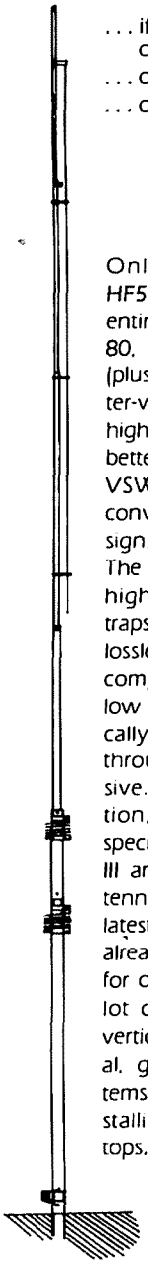
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KENTUCKY: The eleventh annual Greater Louisville Hamfest and Great Lakes Division Convention, September 26 and 27, East Hall, Kentucky Fair and Exposition Center, Louisville. Air-conditioned exhibit area and flea market. For information: Greater Louisville Hamfest, P.O. Box 34444, Louisville, KY 40232. (502) 634-0619.

LOUISIANA: Amacom '81, the New Orleans Hamfest-Computerfest, sponsored by the Jefferson Amateur Radio Club, October 17 and 18, Airport Hilton Inn, across from New Orleans International Airport, Kenner. For information: New Orleans Hamfest-Computerfest, P.O. Box 73665, Metairie, LA 70033.

MARYLAND: The Columbia Amateur Radio Association's 5th annual Hamfest, Sunday, October 11, 8 AM, Howard County Fairgrounds. Admission: $3.00. Tailgating and tables $6.00. Food available. Prizes. Talk-in 147.735/135; 146.52/52. For table reservations and information: Dennis Parra, 6955 Spinning Seed, Columbia, MD 21045.

MASSACHUSETTS: The 19-79 Repeater Association of Chelsea will hold its annual Flea Market, Sunday, October 4, 11 AM to 4 PM (sellers 10 AM), Beachmont VFW Post, 150 Bennington Street, Revere. Admission $1.00. Sellers' tables $6.00 advance; $8.00 door. Talk-in on 19-79 and 52. For table reservations send check to: 19-79 Repeater Association, P.O. Box 171, Chelsea, MA 02150.

MICHIGAN: The Grand Rapids Amateur Radio Association's annual Swap and Shop, Saturday, September 19, Hudsonville Fairgrounds. Door prizes, dealers, indoor/outdoor swap area. Gates open 8 AM. Talk-in on 146.16 - 146.76. For information: Grand Rapids Amateur Radio Association, P.O. Box 1248, Grand Rapids, MI 49501.

MICHIGAN: Adrian Amateur Radio Club's 9th annual Hamfest, Sunday, September 27, Lenawee County Fairground, Adrian. Tickets: $1.50 advance, $2.00 door. Prizes, games, programs, bingo and more. For information and reservations: Adrian Amateur Radio Club, P.O. Box 26, Adrian, MI 49221.

MICHIGAN: Blossomland Amateur Radio Association's 16th annual Hambash, Sunday, October 5, 8 AM to 3:30 PM EST, Lake Michigan College Convention Center, Benton Harbor. Giant flea market, interesting programs. Tables $5.00 each. Tickets: $2.00 advance, $3.00 door. Children under 12 (with families) free. Enjoy a Michigan weekend: cohoffishing, Oktoberfest and more. Talk-in on 22/82 or 52 simplex. For tickets and information: SASE to BARA, P.O. Box 175, St. Joseph, MI 49085.

MICHIGAN: L'Anse Creuse A.R.C.'s 9th annual Swap and Shop, September 20, 0900-1500, L'Anse Creuse High School, Mt. Clemens. Tickets: $1.00 advance, $2.00 door. Prizes: First, $250.00, second $100.00, third, $50.00 plus prize drawings hourly. ARRL, FCC. Talk-in 147.69/09 and 146.52. For information: SASE Mike Corcoran, 650 Chippewa, Mt. Clemens, MI 48043.

MICHIGAN: The Big Rapids Area Amateur Radio Club's First Annual FOX HUNT, October 17, 10 AM, Hemlock Park, Big Rapids. Bring the family; sell or swap Ham gear; win prizes. Refreshments, tables, grills available. Advance/door $3.50 per vehicle. Talk-in 146.52. For information/registration: B.R.A.A.R.C., P.O. ox 1073, Big Rapids, MI 49307.

NEW HAMPSHIRE: The 5th annual Connecticut Valley FM Association's Hamfest/Flea Market, Sunday, September 27, 9 AM to 5 PM, King Ridge Ski Area, New London. Adult admission: $1.00, children under 16 free, flea market set-up $5.00. For information: Connecticut Valley FM Assn., Box 173, E. Wallingford, VT 05742.

NEW YORK: The Radio Amateurs of Greater Syracuse Hamfest, October 3, Art & Home Building, New York State Fairgrounds, Syracuse. For information: RAGS, P.O. Box 88, Liverpool, NY 13088.

NEW YORK: Giant Electronics Flea Market sponsored by the Yonkers Amateur Radio Club, Sunday, October 4, 9 AM to 5 PM, Loral Electronics Parking Lots, Fullerton Avenue, Yonkers. Hourly prizes. Live demonstrations. Free coffee to 10 AM. Auction 3 PM. Admission: Advance $1.50, $2.00 door. Sailers: Advance $4.00, $5.00 door. Bring tables. For further information: Call (914) 969-1053.

NEW YORK: The Long Island Mobile Amateur Radio Club's ARRL Hamfair '81, Part II, September 27, Islip Speedway, Islip. Refreshments available. Awards presented all day. No reservations needed for space. Free parking. General admission: $2.00. Ladies and children free. All licensed Amateurs must pay admission. Heavy rain date October 4. For information: Sid Wolin, K2LJH, (516) 379-2861 or Hank Wener, WB2ALW, (516) 484-4322 nights.

NORTH CAROLINA: The Western North Carolina ARS will hold its Autumnfest, October 10, Asheville Civic Center. Admission: $3.00 advance; $3.50 door. McElroy Memorial CW competition, dealers, flea market, demon-

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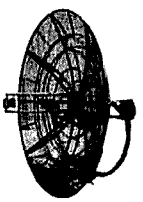
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strations. Talk-in 81/91, 16/76 and 52. For information: WCARS, P.O. Box 1488, Asheville, NC 28802.

OHIO: The 39th Annual Findlay Hamfest, Sunday, September 13, Hancock Recreational Center, east of I-75, exit 161, north edge of Findlay. Prizes include a deluxe low band rig, two Icom IC-2A handhelds, memory keyer, and much more. Tickets $2.00 advance; $2.50 gate. Tables $2.50 per 1/2. Saturday 5 PM to 9 PM for set-up. Sunday 6 AM. For tickets, information and reservations, SASE to P.O. Box 587, Findlay, OH 45840.

OHIO: The Original Forty-fourth Annual Hamfest, Sunday, September 20, 1981, at Stricker's Grove on State Route 128, one mile west of Venice (Ross) Ohio. Exhibits, prizes, food and refreshments available. Flea Market (radio related products only), music, talks, hidden transmitter hunt and sensational air show. Admission and registration $4.00. For information: Lillian Abbott, K8CKI,317 Greenwell Road,Cincinnati, Ohio 45238.

OHIO: The Cleveland Hamfest Association's seventh annual Hamfest, Sunday, September 27, Cuyahoga County Fairgrounds, Berea, 0800 to 1500. Indoor exhibits, forums, ladies' program and outdoor flea market. Three main prizes and a mobile check-in prize. Talk-in on 146.52 with W8QV. Advance tickets $2.50 prior to August 31. $3.00 *door.* Cleveland Hamfest Association, P.O. Box 27211, Cleveland, OH 44127.

OREGON: The Walla Walla Valley Amateur Radio Club's 35th annual Hamfest, Saturday, September 26 and Sunday, September 27, Milton-Freewater Community Building. *Over 100 prizes,* Swap Shop both days, displays. Free registration. 52-52, 19-79, 04-64, 28-88, 16-76 and 3960 KC monitored. For further information: W7DP, Walla Walla Valley ARC, P.O. Box 321, Walla Walla, WA 99362.

PENNSYLVANIA: *The Uniontown Amateur* Radio Club's annual Gabfest, Saturday, September 12, Old Pittsburgh Road, oft Route 51/119 bypass, Uniontown, 40 miles south of Pittsburgh. Pre-registration $2.00 ea./3 for $5.00. Nice prizes. Free swap and shop set-ups/own tables. Starts at noon. Free parking. Talk-in on 147.045/.645 and 146.52 simplex. For information and pre-registration: U.A.R.C. Gabfest Committee, John T. Cermak, WB3DOD, P.O. Box 433, Republic, PA 15475.

PENNSYLVANIA: The 26th annual York County Hamfest, Sunday, September 27, York Fairgrounds, York. 8 AM registration $3.00. Tailgating $2.00. Inside tables $5.00 Fly-in to York Airport. Hourly limo service to Hamfest beginning 9 AM. Hourly door prizes drawn beginning 10 AM. QSL contest. Talk-in on 146.37/97 or 52/52 simplex. For more info: Leroy Frey, 170 S. Albemarle Street, York, PA 17403. (717) 854-1203.

PENNSYLVANIA: The Skyview Radio Club's Swap and Shop, Sunday, September 27, 12 noon to 4 PM, Sokol Camp, 700 Wild Life Road, Lower Burrel. Rain or shine (plenty of shelter in case of rain). Refreshments available. First prize winner need not be present. Check-in on 04-64. Registration $1.00/gate. XYLs, YLs and children no charge. For information: Jim Jackson, K3VRU, RD #1, Box 7A, Apollo, PA 15613.

PENNSYLVANIA: The Pack Rats fifth annual Mid-Atlantic States VHF Conference October 3, Warrington Motor Lodge, Rt. 611, Warrington. Advance registration $3.00, $4.00 door includes admission to HAMARAMA flea market October 4, 8 AM to 4 PM, Bucks County Drive-in Theater, Rt. 611, Warrington. Flea market only $2.00. Tailgating $3.00 per space, own table. Talk-in W3CCX on 52. Information: Ron Whitsel, WA3AXV, P.O. Box 311, Southampton, PA 18966. (215) 355-5730.

SOUTH CAROLINA: The York County Amateur Radio Society's 30th annual Hamfest, Sunday, October 4, Joslin Park, Rock Hill. For information and registration: Y.C.A.R.S., P.O. Box 4141CRS, Rock Hill, SC 29730.

VIRGINIA: ARRL Roanoke Division Convention September 26 and 27 in the Virginia Beach, Virginia Pavillion. Free transportation to the oceanfront where the Neptune Festival is also taking place. FCC Amateur Exams given to those sending form 610 request in advance. Admission $3.50. Advance ticket drawing for FM transceiver. Flea market tables, $5 day, $7 both days. TRC PO Box 7101, Portsmouth, Virginia 23707. 804-587-1695.

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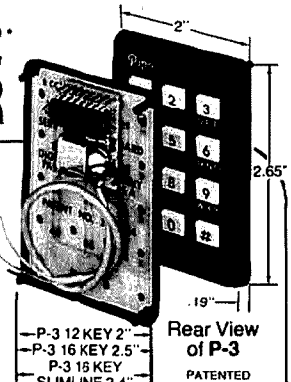
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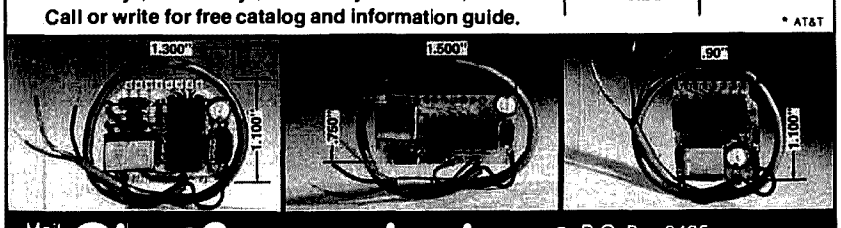
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Labor Day. Contacts will receive a commemorative certificate honoring General Bradley. Operation on the General portion of 40, 20 and 15 meters. Send QSL with SASE to: Tri-County ARC, 601 McKinley, Moberly, MO 65270.

SEPTEMBER 12 & 13: The Cray Valley Radio Society of Great Britain's 11th S.W.L. Contest from 1800 GMT Saturday to 1800 GMT Sunday. 1.8, 3.5, 7, 14, 21 and 28 MHz bands may be used any mode. SASE for log sheets to Owen Cross, G4DFI, 28 Garden Avenue, Bexleyheath, Kent DA7 4LF England. Entries should be sent to Contest Manager, Owen Cross, at above address to arrive not later than November 2, 1981.

SEPTEMBER 12 & 13: The Sweetwater Amateur Radio Club will be conducting a mini-DXpedition to old Ft. Bridger, Wyoming, September 12, 1800 GMT to September 13, 1800 GMT. Ft. Bridger, located in southwestern Wyoming and established in the mid 1800s, is famous for its early day meetings of well-known explorers and mountain men of that time. Frequencies: ± 5 kHz, 7.250, 3.950, 14.300, 21.400, 28.580. CW frequencies will be announced on phone frequencies. A special certificate, depicting the old fort, will be awarded for each contact. A donation of $1.00 is requested for printing, handling and mailing. Mail QSLs to: KB7LZ, D.L. Zwemke, 1010 Bridger Dr., Green River, WY 82935.

SEPTEMBER 19 & 20: The 2nd Annual Dwight Harvest Days QSO party, 0900 to 2000 CDT. 10 through 40 meters SSB and CW on request. 20 meter CW both days on 14.200 ± 5 kc. Call signs: WB9VEL, WD9FGD, WD9FGI, WD9IBF, N9AEE, N9BBE, N9BCC. Certificates to the first 500 contacts on receipt of your QSL.

SEPTEMBER 26 & 27: The Portland (Maine) Amateur Wireless Association's QSO Party. 2300Z Saturday to 2359Z Sunday. Suggested frequencies: CW: 1805 and 55 kHz up from low end of band. Phone: 1815, 3930, 7280, 14280, 21380, 28580 kHz. Novice: 3720, 7120, 21120, 28120. Mail entries by December 1 to: PAWA, Box 1605, Portland, Maine 04104.

SEPTEMBER 26: The Schenectady Amateur Radio Association will operate a special event station, K2AE, commemorating the 150th anniversary of the opening of the Mohawk & Hudson Railroad. Time: 1600Z Saturday to 1700Z Sunday. Frequencies: 7235, 14285 and 21360. Amateurs desiring QSL from contact with K2AE SASE to K2AE.

SEPTEMBER 26: The twelfth annual Delta QSO party sponsored by the Delta Division of the ARRL from 1800Z Sept. 26 to 2400Z Sept. 27. Suggested frequencies: CW: 3550, 7050, 14050, 21050, 28050. SSB: 3990, 7290, 14290, 21390, 28590. Novice: 3725, 7125, 21125, 28125. Logs must be postmarked no later than October 21 to be eligible for awards and will be returned if requested. Send logs to: Malcolm P. Keown, W5XX, 213 Moonmist, Vicksburg, MS 39180.

SEPTEMBER 26 & 27: The Beaumont (Texas) Amateur Radio and Repeater Club's station, W5RIN, will be operating during the 80th anniversary of Spindletop, the famous Lucas gusher. Times for both days 1700Z to 2300Z. Time allotted for CW in the low 25 kHz of the Novice 10-15-40 meter band. Phone contact in the low 25 kHz of the General portion of 10-15-20-40 meter band. Listen for CQ Spindletop on phone and CQ SP on CW. For a beautiful certificate and brochure on the history of Spindletop send QSL and $1.00 to Certificate Manager, BAR&RC, 3090 S. Major Drive, Beaumont, TX 77707.

OCTOBER 10 & 11: The Hamfesters Radio Club will be operating on the General phone portion of 10 and 40 meters and the Novice portion of 10 meters from 1700 UTC October 10 to 1700 UTC October 11. Applicants wishing a WAHM (Worked All Hamfesters Members) award send list of contacts to: P.O. Box 42792, Chicago, IL 60642.

OCTOBER 17 & 18: 24th Jamboree on the Air. Hams and Scout groups get-together. Scouts — Amateur radio clubs have lists of members or SASE to American Radio Relay League, Sally O'Dell, Youth Activities Director, 225 Main St., Newington, CT 06111. Time: Generally 0001 UTC Saturday to 2400 UTC Sunday. Contacts: No required format. Scout frequencies: 3740, 7090, 14290, 21360, 28990, (phone). 3590, 7030, 14070, 21140, 28190, (CW). SSTV and RTTY on usual frequencies. For certificates SASE to: JOTA Coordinator, Harry Harchar, W2GND, 216 Maxwell Avenue, Hightstown, NJ 08520.

OCTOBER 17: The 24th annual Pennsylvania WSO party, 1700Z October 17 to 0400Z October 18; 1300Z October 18 to 2200Z October 18. Frequencies: SSB: 3980, 7280, 14280, 21380, 28580. CW: 40 kHz up from bottom of CW bands. Mail logs with SASE by November 15 to: Douglas R. Maddox, W3HDH, 1187 S. Garner Street, State College, PA 16801.

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The Hustler G7-220 MHz (1-1/4 meter) Amateur vertical fixed-station antenna has a suggested list price of $142.95 and is available now. For further information write Sales Department, Hustler, Inc., 3275 North B Avenue, Kissimmee, Florida 32741.

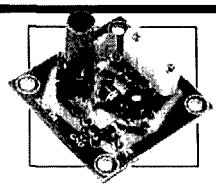
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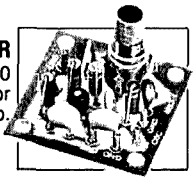
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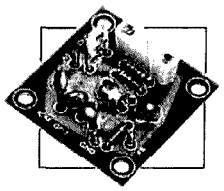
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Crystal controlled transistor type. 3 to 20 MHz, OX-Lo, Cat. No. 035100. 20 to 60 MHz, OX-Hi, Cat. No. 035101.
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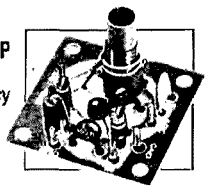
MXX-1 TRANSISTOR RF MIXER
A single tuned circuit intended for signal conversion in the 3 to 170 MHz range. Harmonics of the OX or OF-1 oscillator are used for injection in the 60 to 170 MHz range. 3 to 20 MHz, Lo Kit, Cat. No. 035105. 20 to 170 MHz, Hi Kit, Cat. No. 035106.
Specify when ordering. $7.02 ea.

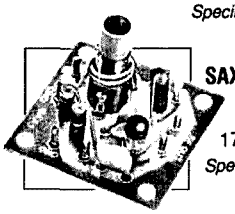




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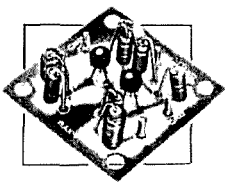
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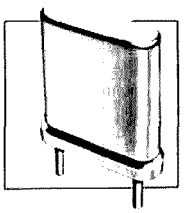




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More Details? CHECK—OFF Page 98

NEW products

the bandwidth will remain constant regardless of changes in the frequency-range setting. This feature has not been readily available in variable filters until now.

The varifilter has its own internal power supply which is switchable from 115 Vac to 230 Vac. It is able to run from 12 to 18 Vdc as well. Each unit has a tuning eye that lets the operator see when he has filtered the signal he wants to.

A full-year warranty backs the varifilter. It is available from Kantronics dealers and from the factory. Suggested retail price of the varifilter is $139.95.

For further information contact Kantronics, Inc., 1202 E. 23rd Street, Lawrence, Kansas 66044.

mobile antenna

Avanti Communications has recently modified its 5 dB gain on-glass mobile antenna designed for use in two-way and Amateur Radio communications.

The new 3/4-meter, 410-512 MHz AP450.5G featues a straight 30-inch whip with a small center-position phasing coil. By popular request the former loop section has been eliminated and replaced with a small, sleek coil measuring only 1-1/2 inches in length and a maximum diameter of 3/8-inch, making it the smallest UHF 5-dB-gain whip and phasing coil combination on the market.

As with each of Avanti's on-glass communications antennas, the new AP450.5G offers improved performance, requires no holes be drilled, features shorter installation time, and requires no metal ground plane. Thus it may be used in many more applications than conventional mobile antennas.

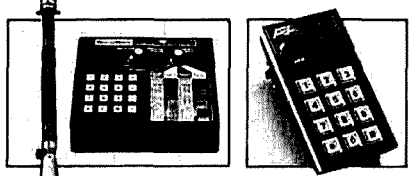
For more information contact Avanti Communications, 340 Stewart Avenue, Addison, Illinois 60101.

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HAM CALENDAR

September

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			AMSAT Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **2**	**3**	**4**	ILLIANA REPEATER SYSTEM'S 12TH ANNUAL DANVILLE AREA HAMFEST – Georgetown Fairgrounds, Georgetown, IL. WD9AFG **5-6** **5**
BLOOMINGTON ARC "HOOSIER BACKYARD HAMFEST" – 2335 Vernal Pike, Bloomington, IN – K9KTH **6** **6**	**TRI-COUNTY ARC** – Special Events Station from 10 AM to 6 PM around 40, 20, and 15 meters. For certificate send QSL with SASE to Tri-County ARC, 601 McKinley, Moberly, MO 65270 **7** **WEST COAST BULLETIN** – 8 PM EST (0400 UTC), 3540 kHz, A1, 22 WPM **7** **7**	**8**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **9**	**YLRL "HOWDY DAYS" PARTY** 9-11 **10**	**11**	**UNIONTOWN ARC ANNUAL GABFEST** – Held on the club grounds on the old Pittsburgh Road off Rtes. 51 & 119 in Uniontown, PA – WB3OOO **12** **SWEETWATER ARC DXPEDITION** – to Ft. Bridger, WY. Operation from 1800 GMT on the 12th to 1800 GMT on the 13th – KB7LZ **12** **SUSSEX COUNTY ARC 3RD ANNUAL HAMFEST** – Sussex County Farm & Horse Show grounds off Rte. 206, Augusta, NJ – WA2LHX **12** **CRAY VALLEY RADIO SOCIETY (UK) 11TH ANNUAL SWL CONTEST** – from 1800 GMT on Sept. 12th to 1800 GMT on Sept. 13th. 1.8, 3.5, 7, 14, 21 and 28 MHz bands may be used – G4DFI **12-13** **EUROPEAN PHONE CONTEST** – **12-13** **12**
SOUTH JERSEY RADIO ASSOCIATION 65TH ANNUAL HAMFEST – Pennsauken H.S., Remington Ave. & U.S. Rte. 73, Pennsauken, NJ – W2SPV **13** **SUFFOLK COUNTY RADIO CLUB'S 4TH ANNUAL ELECTRONIC FLEA MARKET** – Odd Fellows Hall, Jayne Blvd., Port Jefferson, L.I., NY. Contact Floyd Davis at 516-234-9376 **13** **HALL OF SCIENCE ARC SIXTH ANNUAL HAMFEST** – Municipal Parking Garage one block North of Queens Blvd., 80-25 126 St., Kew Gardens, Queens, NY. Contact Tom Doyle KA2DTB **13** **38TH FINDLAY HAMFEST** – Hancock Recreational Complex east of I-75 exit 161 on North edge of Findlay. SASE to P.O. Box 587, Findlay, OH 45840 **13** **BRISTOL COUNTY AMATEUR RADIO ASSOCIATION FLEA MARKET** – V.F.W. hall in Tiverton, RI. Contact Ann Carro WKA2DNB (SASE) **13** **13**	**WASHINGTON STATE QSO PARTY** – **12-14** **W1AW QUALIFYING RUN** 14 **14**	**15**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **16**	**17**	**HAM-O-RAMA 81** – Erie County Fairgrounds south of Buffalo, NY. Contact Nelson Oldfield, 126 Greenway Blvd., Cheektowaga, NY 14225 or Mike Merrick, 419 Summerville Ave., Tonawanda, NY 14150. **18-19** **18**	**GRAND RAPIDS AMATEUR RADIO ASSOCIATION'S ANNUAL SWAP & SHOP** – Hudsonville, MI Fairgrounds. Contact Grand Rapids ARA, P.O. Box 1248, Grand Rapids, MI 49501 **19** **DWIGHT O.A.R.S. SPECIAL OPERATING EVENT** – 0900 to 2000 CDT 10m thru 40m and will work 20m CW on 14.200. N9AEE **19-20** **CHICAGO FM CLUB'S RADIO EXPO 81** – Lake County Fairgrounds, Rtes. 45 and 120, Grayslake, IL. Call (312) BST-EXPO **19-20** **PEORIA ARC SUPERFEST 81** – Exposition Gardens, W. North Industrial Rd., Peoria, IL – WD9EGW **19-20** **ANNUAL DAKOTA DIV. CONVENTION OF THE ARRC** – Rochester, MN, Downtown Holiday Inn – N0BJO **19-20** **NEW ENGLAND DIVISION CONVENTION** – Hartford, CT **19-20** **19**
CANDLEWOOD AMATEUR RADIO ASSOCIATION'S FLEA MARKET – Essex House, Rte. 6, Newtown, CT. WB2THN **20** **GREATER CINCINNATI AMATEUR RADIO ASSN. 44TH ANNUAL HAMFEST** – Stricker's Grove on Ohio State Rte. 128 – K8CKI **20** **AUGUSTA, GA. ARC ANNUAL HAMFEST** – Julian Smith Casino, Diane – WB4YHT **20** **L'ANSE CREUSE A.R.C. SWAP SHOP** – L'Anse Creuse H.S., Mt. Clemens, MI. Contact Mike Corcoran, N8CEN (SASE) **20** **6TH ANNUAL HAMFEST & ELECTRONIC FLEA MARKET** – 4-H Fairgrounds, Argos, IN. Contact Paul DeVos, WB9VFJ **20** **20**	**WEST COAST BULLETIN** – 8 PM EST (0400 UTC), 3540 kHz, A1, 22 WPM **21** **21**	**22**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **W1AW QUALIFYING RUN** 23 **23**	**24**	**25**	**W7DP 35TH ANNUAL HAMFEST** – Milton Freewater Community Bldg., Milton-Freewater, OR **26** **SCHENECTADY AMATEUR RADIO ASSN.** – Special Event Station K2AE, 1600Z Sat. to 1700Z Sun. on the following plus or minus QRM: 7235, 14.285 & 21.360. Send SASE to K2AE for QSL card **26** **MAINE QSO PARTY** – from 2300Z Sat. to 2359Z Sun. Contact B.G. Cohen K1SA, 980 Forest Ave., Portland, ME 04103 **26** **GREAT LAKES DIVISION CONVENTION & 11TH ANNUAL GREATER LOUISVILLE HAMFEST** – East Hall of Kentucky Fair & Expo Center, Louisville, KY 40232 – K4GDL **26-27** **AHHL HUANUKK DIVISION CONVENTION** – Virginia Beach Pavilion. Contact TRC, P.O. Box 7101, Portsmouth, VA 23707 **26-27** **DELTA QSO PARTY** **26-27** **26**
CALHOUN COUNTY AMATEUR RADIO ASSN. 2ND ANNUAL HAMFEST – Municipal Auditorium, 1128 Gurnee Ave., Anniston, AL – KA4LRL **26-27** **GOLDEN EMPIRE FLYING CLUB'S ANNUAL FLY-IN & AVIONICS SWAP MEET** – Nevada County (CA) Airpark. Contact Golden Empire Flying Club, P.O. Box 375, Grass Valley, CA 95945 **27** **7TH ANNUAL CLEVELAND HAMFEST** – Cuyahoga County Fairgrounds in Berea, OH. Contact Cleveland Hamfest Association, P.O. Box 27211, Cleveland, OH 44127 **27** **LANIERLAND A.R.C. HAMFEST** – Gainesville, GA. at the Holiday Inn. Contact Paul Watkins, W4FDK **27** **SANGAMON VALLEY RADIO CLUB'S SIXTH ANNUAL HAMFEST** – Sangamon County Fairgrounds, U.S. Rte. 36, New Berlin, IL **27** **7TH ANNUAL CEDAR VALLEY ARC HAMFEST** – Hawkeye Downs Exhibition Bldg., Cedar Rapids, IA. Contact CVARC Hamfest, P.O. Box 994, Cedar Rapids, IA 52406 **27** **CONNECTICUT VALLEY FM ASSOCIATION'S 5TH ANNUAL HAMFEST** – King Ridge Ski Area, New London, NH. KA1BWE **27** **LONG ISLAND MOBILE ARC ARRL HAMFAIR 81 PART II** – Islip Speedway, Islip, NY at Exit 43 of Southern State Pkwy. Contact Sid Wolin, K2LJH **27** **SKYVIEW RADIO CLUB SWAP & SHOP** – Solku Camp, 700 Wildlife Rd., Lower Burrell, PA. Contact Jim Jackson, K3VRU **27** **ADRIAN ARC HAMFEST** – Lenawee County Fairgrounds, Adrian, MI. Contact Adrian ARC, P.O. Box 26, Adrian, MI 49221 **27** **27**	**28**	**29**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **30**			

W1AW Schedule
April 26-October 25, 1981

UTC	Slow Code Practice	MWF: 0200, 1300, 2300; TThSSn: 2000; S: 0200
	Fast Code Practice	MWF: 2000, TTh: 0200, 1300; TThSSn: 2300; S: 0200
	CW Bulletins	Dy: 0000, 0300, 2100; MTWThF: 1400

Code practice and CW bulletin frequencies: 1.835, 3.58, 7.08, 14.08, 21.08, 28.08, 50.08, 147.555 MHz

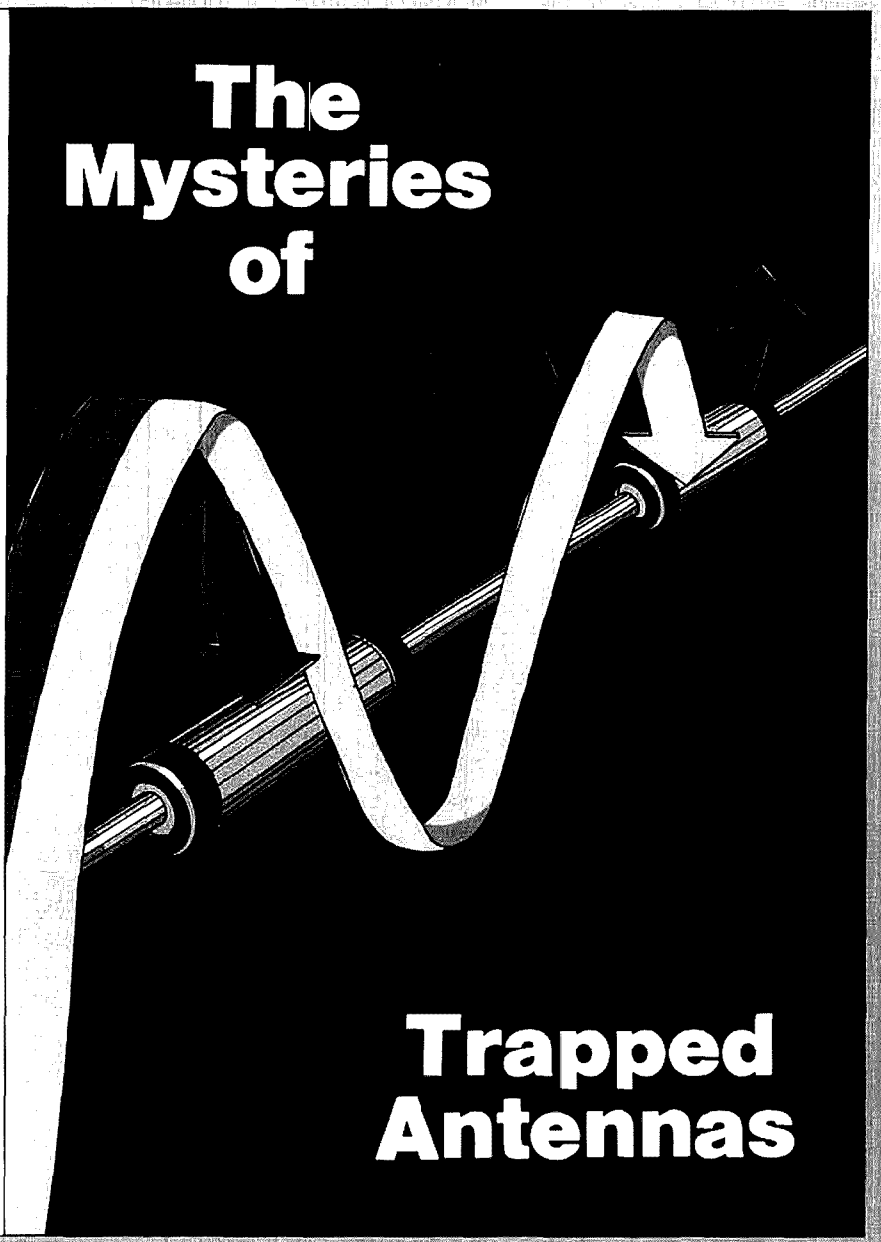
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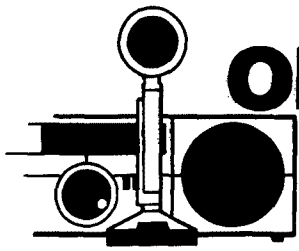
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Observation & Opinion

From time to time I tune across the Novice bands just to see what's going on and to learn how the beginners are developing their operating skills. I sometimes fire up my rig and work a few Novices. In most cases the Novices appreciate a more experienced CW operator invading their territory, especially if the latter is patient and understanding. I recommend that all experienced CW operators take the time to work a few Novices. It's a welcome change from fighting the pile-ups and gives a sense of accomplishment, especially if you've helped a Novice improve his code proficiency and operating procedures.

Listening on the Novice frequencies can be an interesting experience. The Novice portion of the 40-meter band is a good example. Here you'll find some operators who are pretty good — their sending, although not fast, is clear and clean, and their operating techniques are on a par with those of many General-class operators. A few have electronic keyers or keyboards, but most plod along with a straight key. At the other end of the scale, you'll find Novices who just can't seem to break bad operating habits. This is where an experienced CW operator can really help, but it takes a lot of patience and, above all, tact.

Many Novices don't know what to do after they've called CQ. The over evening I heard a station sending CQ continuously at a rapid rate for three minutes, followed by his call sign, which was sent only once. After a pause of a few seconds, the CQing started again. This was repeated for another three or four minutes — still no response. Then I tuned up the band a few kilohertz, and there was another Novice calling CQ. The same pattern was again repeated — no response. All in all, I heard perhaps ten stations across the Novice portion of the band calling CQ. One wonders if they had their receivers turned on.

Then I tuned back to the first station and there he was, still at it. When he signed this time I gave him a call, being particularly careful to match my sending speed to his. I signed over — nothing. Then, "QRZ? QRZ?" I sent my call again at his speed. Again, "QRZ?" This went on for a few minutes, then I reduced speed to about half and the Novice finally answered. We had a pleasant contact for a while, with the Novice sending at a considerably slower rate than before, complete with all the punctuation marks.

I mentioned earlier that many Novices don't know what to do after calling CQ. I find that many Novices, after returning to the receive mode, don't tune around their transmitting frequency. Apparently they expect the replying station to be exactly on their transmitting frequency, which is unlikely in many cases. If the Novice is using a sharp CW filter in the receiver, the answering signal could be outside the receiver i-f passband and will never be heard.

The best answer to the CQ problem is don't. Old-timers will recall a filler cartoon that used to run in *QST* years ago. It showed a mama cat walking along the top of a fence, followed by three kittens. The caption was, "If you wanna get results, you gotta make calls!" Not only did it mean CQ calls but also calls to other stations.

Another recollection of bygone days is the series of pieces in *QST* by T.O.M. (The Old Man). T.O.M. loved to write about "Rotten Radio." His poignant prose was directed to everything from rotten spark sets to rotten operating. I think we could use more of T.O.M.'s scathing criticism. Although he wrote in a humorous vein, there was a lot of truth in his observations. I'll bet if T.O.M. were alive today, he would endorse my sentiments about the operating practices of some of our Novices. I feel it's the responsibility of the higher-class operators to give a little of themselves to assist those Novices that need help.

Alf Wilson, W6NIF
editor



comments

filter design

Dear HR:

I am writing to tell you that I enjoyed reading the "Rf Power Meter" article by Ralph Fowler, N6YC, that appeared in the June issue. I was particularly interested in Mr. Fowler's discussion of the directional bridge and its associated accessories. I noted that several of Mr. Fowler's accessories were lowpass and bandpass filters, and he referred the reader to the ARRL *Handbook* for lowpass filter construction information. In my opinion, there are more useful references than the ARRL *Handbook* for the design of the seven-pole LC lowpass filters used by Mr. Fowler, and I wish to bring these references to the attention of Mr. Fowler and the readers of *ham radio*.

Since 1972, I have had many articles published on passive LC filter design (references 1 through 8) in which tables of pre-calculated designs required only standard-value capacitors to simplify construction. The most recent article[5] on this design aid was published in the January 7, 1981, issue of *EDN*. I recommend this last reference to Mr. Fowler and your readers for the expeditious design and construction of the seven-element lowpass filters mentioned in the article. (Table 2 of the reference is probably more useful for Amateur Radio applications than is table 1).

For example, on page 59 of his article, Mr. Fowler states he uses "seven-pole LC lowpass filters with cutoffs at 5.8, 9.6, 15.7, 23.1, and 30.4 MHz" to attenuate the harmonic amplitudes of his signal generator. These designs can be conveniently selected from my table 2 and only standard-value capacitors are needed. Also, all of the messy calculations are eliminated. For the previously listed cutoff frequencies used by Mr. Fowler, I suggest Filter Designs #207, 232, 138, 162, and 173, respectively. These designs have reflection coefficients of less than 9.2 percent, and they should perform satisfactorily in this application. I will be happy to provide anyone with a copy of my article if they send me a stamped, self-addressed envelope.

To further demonstrate how standard-value capacitors can simplify filter design and construction, I have made minor modifications to Mr. Fowler's 5.3-MHz Butterworth bandpass filter (fig. 9, page 61 of his article). The Butterworth design was modified into a Chebyshev design that is easier to construct, and the passband and stopband performance of the two designs is very similar (see my fig. 1 of bandpass filter responses). (The Chebyshev design was based on my tabulation of precalculated five-element lowpass filters that was published in June, 1978 — see reference 6.) Note that the inductor values of the two different de-

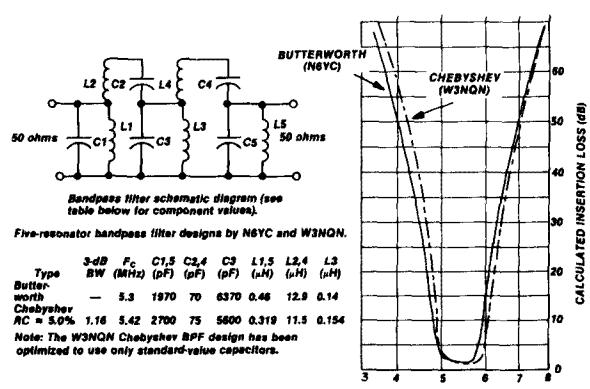


fig. 1. Calculated bandpass filter responses based on an inductor *Q* of 100 at 5.3 MHz.

signs are very similar, and therefore the inductors of the Chebyshev design should be just as feasible to obtain as the Butterworth designs. If the bandwidth of the filter is made too small, the ratio of inductance values (L2 to L1,5) will become too large, thus making it difficult to get good inductor Q and proper filter performance. The filter bandwidth selected by Mr. Fowler seems reasonable from a construction and performance viewpoint. Capacitor values C2 are similar (70 pF compared with 75 pF) but C1,5 and C3 are quite different. This difference is a consequence of changing the Butterworth design into a Chebyshev design. Mr. Fowler's center frequency of 5.3 MHz was slightly increased to 5.42 MHz to make C2,4 come out to a standard capacitor value (75).

Mr. Fowler was correct in his concluding sentence that "improvements doubtless can be made," and this I have attempted to demonstrate as far as the passive LC filter design aspect is concerned. I am grateful to Mr. Fowler for taking the time and effort to write his articles, and I thank *ham radio* for publishing them. I hope to read many more similar articles which will assist me and others in improving our technical expertise.

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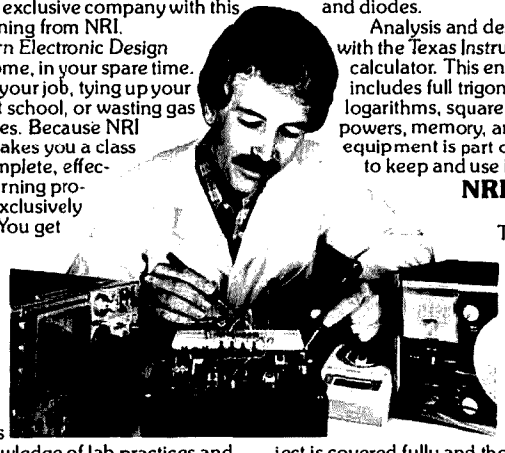
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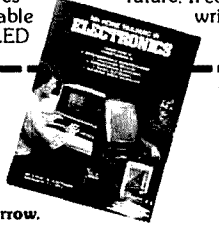
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FCC'S STAFF REPORT was finally issued July 16, and the 92-page document contains a number of inferences and suggestions that should cause concern in the Amateur community. Although the report cites CB radio as the greatest single source of RFI complaints, Amateur Radio is almost invariably mentioned along with CB in discussions of problems and solutions. "The problems created by radio frequency interference (RFI) are serious and getting worse," the report's chapter on recommendations begins, and then in the very next paragraph it states, "A significant part of the RFI problem is TV receiver overload caused by CB radio (and to a lesser extent amateur radio)."

Among The Proposed Solutions (to TV set overload by CB radio) are mandatory or voluntary TV receiver standards and TV receiver labeling (as to performance). Another option would be to set a combined transmitter/receiver limited liability, which could (for the transmitter operator) include adding filters, limiting antenna height (or direction), quiet hours, or even compensating the person interfered with! Another option, even more onerous, would place all burden for TVI resolution on the transmitter operator.

This Last Interference "Remedy" comes up several times in the Commission's staff report, and would certainly be very objectionable to the Amateur service. With it an Amateur could be forced to reduce power, move or modify antennas, avoid certain bands, or even give up operating entirely in order to resolve an interference problem. This alternative remedy does seem to have some support, however, as it comes within the present authority of the FCC. The alternative remedy, regulation to require better interference rejection by home entertainment devices, is one that would require new legislation, such as Senator Goldwater's bill, S929.

A Further Notice Of Inquiry on the RFI question, General Docket 78-369, was issued along with the staff report. Reply Comments are due on November 16.

SIGNIFICANT RULES RELAXATIONS have been suggested for the Amateur Service in an FCC working paper, "Deregulating Personal and Amateur Radio." The recently released 80-page document, more a "brainstorming session" of the possible directions Amateur and CB deregulation might take than hard and fast proposals, was prepared by the Commission's Office of Plans and Policy.

Repeater Rules Are Discussed in the paper, which suggests reducing the responsibility control operators have for repeater control or eliminating it completely, and changing the prohibitions on repeaters below 29.5 MHz. Some restrictions on third-party traffic could also be relaxed; the working paper is very strong on "deregulation or liberalization of restrictions that may inhibit new technology," and suggests that the rules now restrict or even prohibit Amateur experimentation with packet radio, spread spectrum, and other new communications developments.

A Code-Free VHF License "for technically qualified applicants" might strengthen Amateur Radio's technological orientation it further suggests, along with improving utilization of the 28-MHz band by giving Technicians some phone privileges there. It also considers the possible benefits of allowing "some Amateur operations on 27 and 900 MHz Personal Radio Service (CB) frequencies."

The Personal Radio Service and how it can best use the new 900-MHz band occupies the bulk of the working paper. The adoption of various new communications techniques and the expansion of personal radio into landmobile business communications, mobile and rural radiotelephone, and even marine radio are subjects which receive even more attention than the Amateur Service does in the paper.

Though The Deregulation Ideas presented in the working paper are simply ideas at this time, they deserve consideration, as they represent some recent FCC thinking. A very few copies of the paper were available from the Commission; reproductions are also offered by Fair Press Services, (202) 463-7323, and the Downtown Copy Center, (202) 452-1422, at about $8.00 a copy.

Amateurs With Comments on the working paper can contact Alex Felker, Office of Plans and Policy, FCC, Washington, D.C. 20554.

ARRL HAS BEEN SUED FOR $50,000 by three members of the Indiana Radio Club Council, who allege in their complaint that "the defendant (ARRL) refuses to hold a recall vote" in the Central Division. League General Manager Dick Baldwin had acknowledged receipt of the Council's recall petition in a July 29 letter, in which he stated the petition had been put on the September 9 Executive Committee meeting agenda.

The First Hearing on the suit was set for September 25, in the U.S. District Court in Indianapolis.

A NEW WORLD LAND SPEED RECORD will be attempted starting on September 28 at the Bonneville Salt Flats in Utah. A special-event station with SSTV pictures of the attempt, being made by Thrust Cars Ltd. from England, will be active October 3, 4, 10, 11, 17, 18, and 24 starting at 1500Z. Frequencies will be 14240 and 21340 for SSTV, and 14290 and 21370 for SSB QSOs. Operating as WA7MTF, the Amateurs will also provide ATV along the 11-mile strip for crowd control.

trapping the mysteries of trapped antennas

A quantitative treatment of antenna trap design and construction

By Gary E. O'Neil, N3GO, 13 Holiday Hill Road, Endicott, New York 13760

Much information is available pertaining to antenna design and construction. Most of this information is written for a technically competent audience and addresses the problem of antenna performance under nearly ideal conditions. With 17 years in Amateur Radio, I have yet to live in a location where compromises are not required. One very popular compromise is the use of traps to achieve multiband operation with a single antenna.

The use of traps in commercial designs, such as verticals and triband beams, has been an accepted technique for many years. Although design guidelines are available, a quantitative definition of what is required and acceptable does not seem to exist. I was puzzled about trap designs and asked why a compromise in performance should be costly. Owning a transceiver that covers 160 through 10 meters, I wanted to use as many of the bands as possible. Separate antennas for each band were out of the question because of limited space. Having no previous experience with trapped antennas, I decided it was the right time to gain some.

what is required?

I began reading assorted handbooks and college texts. I reviewed back issues of magazines and queried colleagues. I was surprised to discover how little information is available about traps, much less their use in antennas. The following information was derived from my research:

1. Traps are parallel-resonant tuned circuits that provide an effective open circuit at their resonant frequency.

2. Traps become a series inductance at frequencies below resonance, electrically lengthening the antenna. This implies that the physical length of the antenna is shorter at lower frequencies because of the inductance provided by the coil component of the trap.

3. Traps must have a high Q.

4. High-Q capacitors must be used.

5. Large-diameter coils are recommended.

6. Capacitors and inductors providing 200 to 300 ohms of reactance at resonance provide good results.

7. Traps must be resonant very near the center of the band for which they are designed.

I needed answers to some basic questions to determine the requirements of a trap:

1. What is an effective open circuit?

2. How high is high Q?

3. How large is a large-diameter coil?

4. How close to the desired frequency must a trap be resonant?

5. What effects do traps cause at the band edges?

6. How much do traps shorten an antenna?

7. How do I tune an antenna with traps?

I'd be dishonest if I claimed that I asked all these questions at once and that my initial results were where this story ends. Actually, I went through two designs before developing the trap described here and evaluated one commercially manufactured design for comparison of performance. As I progressed, I found I had questions not answered by colleagues or reference books. Some crude testing was in order.

high Q or high impedance?

I needed to know what an effective open circuit was, and my test for this was quite simple. I built a 20-meter dipole as my reference antenna and assumed that adding a high-value resistor in series with the length of wire on the end would be like adding a high-Q trap and wire for a lower band when operating on 20 meters. I assumed a quarter wavelength on 20 meters to provide a worst-case mismatch of the antenna. I cut some wire to 16.5 feet (5 meters) in length and spliced a resistor to one end; then I connected this wire onto one end of my dipole at the opposite side of the resistor and measured the VSWR. The following results were obtained:

resistor value (kilohms)	VSWR
2.7	2.8 to 1
3.9	2.6 to 1
6.8	2.2 to 1
10.0	1.7 to 1

The VSWR of the antenna before this test was less than 1.2 to 1. I conducted the test where the antenna was best matched to get a feel for the contribution to overall VSWR.

It appears that an impedance greater than 7 kilohms must be maintained to ensure a 2:1 VSWR. A lower trap impedance can be used and compensated for by adjusting antenna lengths; but in *this case the* loading effect would have caused an interaction and tuning for resonance on all bands would be a frustrating experience.

While studying my impedance data and considering Q, I became a bit perplexed. As losses approach zero, Q approaches infinity and bandwidth approaches zero. If this were true, the trap would be useful at one frequency only. Zero bandwidth was not my problem. Given bandwidth and center frequency, I can calculate Q, as illustrated by this example:

Given: $F_c = 14.175\,MHz$ (center of 20 meters)

$3\,dB\,BW = 0.35\,MHz$ (width of 20-meter band)

Therefore:

$$Q = \frac{F_c}{3\text{-}dB\,BW} = \frac{14.175}{0.35} = 40.5$$

It follows that high Q is 40.5 on 20 meters and is valid if, at F_c, the impedance is equal to 14 kilohms. The impedance at the band edges in this case would be 7 kilohms, which is sufficient for a 2:1 match and assumes that the antenna and traps are tuned to 14.175 MHz exactly.

A Q of 40.5 and an impedance of 14 kilohms at resonance can be achieved with a wide variety of LC combinations and assorted types of capacitors.

Now assume Q remains constant but impedance increases at F_c. The effect is a higher impedance across the band. If the impedance at F_c remains constant and Q gets larger, the impedance at the band edges is reduced. This implies a problem, since my crude measurements indicate a need to maintain greater than 7 kilohms across the band.

My point is, *high Q may not be desirable in antenna traps*. It's important to understand that the property of the trap providing isolation is its *impedance*. It is this impedance that must be kept large. Anything larger than 7 kilohms improves isolation and is therefore desirable.

A little experience will clarify the fact that, as Q increases, the impedance at F_c increases. This is perhaps the reason why high-Q traps are considered a must for good performance. I intend to show this is not true and attempt to explain the contribution of Q to losses and bandwidth rather than to impedance at resonance.

questions answered

The most helpful reference I could find for an answer to my original question suggests that high Q is approximately 100, and a Q of 50 would be considered medium. Aside from answering my original question, this information served no useful purpose. The same is true for high-Q capacitors. Strictly speaking, Q refers to *losses in this case rather than* bandwidth. And if capacitors are used, the higher the Q, the better should be your guide. High-voltage capacitors are popular but are generally expensive and difficult to find.

Large-diameter coils seem to imply 2-3 inches (5-7.5 cm), although most triband beam manufacturers do well with smaller diameters. This information,

along with the recommended 200-300 ohms of reactance at resonance, have worked well in the past; and experiments with trap designs of the more conventional type tend to support these recommendations. For this reason, I will not oppose the theories on which they are based.

I attempted a number of trap designs, looking for a low-cost, easily manufactured capacitor. Gary Myers, K9CZB,[1] used coaxial cable for the capacitor in his 7-MHz trap. My tests revealed an impedance of 50 kilohms at F_c for a 15-meter version using an HP-4815A *Vector* Impedance Meter. Its Q was high (approximately 126); and to ensure 7 kilohms at the band edges, the center frequency had to be accurate and stable. With a bit of persistence, careful thought, and some RG-58/U, I was able to develop the trap described here.

theory

The single-element trap simultaneously uses three physical properties that can be realized with a section of coaxial cable. Using the properties of capacitance, inductance, and coupling reduces the complexity of LC networks to an appropriately configured length of coax in the form of a coil. Models have been built, tested, and evaluated in the 3.5- to 30-MHz range and calculations verified to 150 MHz with a reasonable accuracy.

A properly designed and manufactured coaxial cable has a uniform capacitance per unit length,

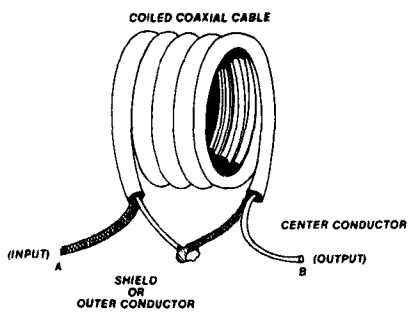


fig. 1. Single-element trap wiring detail.

which is predictable, between the center conductor and shield. This capacitance can be employed in an LC network such as a tank circuit, which presents a high impedance at resonance.

A second property is that coax can be coiled. The forming of a conductor (the coax shield in this case) into a coil produces an inductance greater than that of the wire alone, due to coupling between turns. This is predictable and can serve as the inductive component in an LC network. It should be noted that only the shield is considered to be coiled and is the significant contributor to the inductive component of the trap.

Since the center conductor is shielded, the effects of coiling the cable do not influence the center conductor, which maintains a given inductance per unit length of the wire alone. Although this property has negligible effect on the operation of the trap to be described and was omitted from the calculations, one should be aware of it for applications at or near microwave frequencies. The important point is that the capacitance per unit length remains unchanged by coiling the cable due to the shielding properties of the outer conductor.

configuration

With the source of capacitance and inductance defined, the task of wiring the device remains. Fig. 1 illustrates this requirement and shows the cable coiled as described. It is shown without a form for support

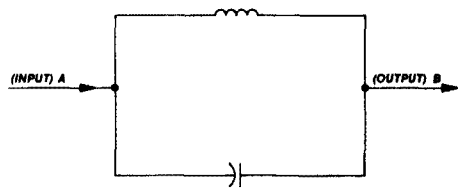


fig. 2. Electrical schematic of an antenna trap.

as an illustrative aid. If flexible cable such as RG-58/U is used, a rigid form such as PVC plumbing stock would be required.

Fig. 2 is the schematic representation of a parallel LC network with external connections designated **A** and **B**. Notice that a dc path must be provided between terminals **A** and **B**. Also, each plate of the capacitor connects to opposite ends of the inductor. **A** casual look at fig. 1 may cause some confusion since it appears that, with the center conductor connected to the shield, the cable's capacitance is short circuited. This is valid only at dc as is the case in the circuit shown in fig. 2. An analysis of the phase relationships required at resonance will reveal why this connection is not only valid but is also required.

The third property of the coaxial cable is the coupling between the center conductor and shield due to magnetic induction. This property (the basis of transformers) is clearly seen if viewed as a straight length of cable. Fig. 3 shows this schematically as two parallel conductors revealing the necessary components of a 1 to 1 transformer, or more aptly, a coupler. Cur-

rent injected into the primary from some source induces a secondary current in the opposite direction as indicated by the arrows. Connecting the top of the secondary to the bottom of the primary causes primary and secondary currents to oppose each other. These currents, being equal and opposite, aid the opposition of the network to current flow. At resonance, the trap has a high circulating current enhancing the coupling properties, which further improves this opposition.

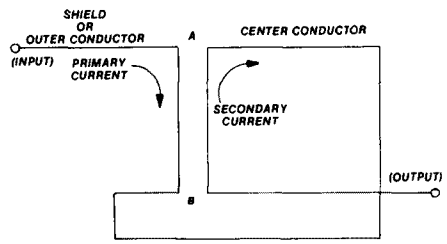


fig. 3. Electrical schematic of single-element trap as a 1:1 transformer or coupler.

With the cable configured as shown in **fig. 1** and referring to the schematic in **fig. 2**, one might assume that the input and output connections should be at the ends of the shield. This provides the tank circuit function using only the properties of inductance and capacitance. Magnetic induction is not employed when one end of the secondary remains open circuited. The connections indicated provide the return path for secondary current, and an analysis of phase relationships at resonance will validate this connection.

The inductance of the center conductor now included causes a slight shift downward in resonant frequency and was observed to be about 2.5 percent in a 15-meter trap. The significant result of this connection is the gain in impedance produced by the opposing primary and secondary currents with no detectable change in Q relative to the 3-dB bandwidth of the device. Test data provided at the end of this article illustrates the significance of this impedance gain.

Tests of traps using conventional LC configurations indicate this trap has much lower Q (wider bandwidth) but provides a comparable impedance at resonance, implying similar loss characteristics. High impedance and relatively low Q make this design superior, since the accuracy to which it is tuned and its physical stability become less critical. *The result is a trap that does not need tuning.*

In addition to these profound advantages, the cost is near zero. If you are considering erecting an antenna, you will likely have coax as your feedline. A local plumbing contractor may be a good source for discarded PVC stock sufficient for these traps.

Q versus loss

Does the low Q of the single element trap imply that it is lossy? This must be answered with another question. What is low loss? **Fig. 2** represents a tank as a capacitor in parallel with an inductor. If this were an exact representation, the impedance at resonance would be infinite. Mother nature plays her role and introduces loss represented by a resistor in parallel with the tank.

At resonance, the impedance is infinity in parallel with the resistor representing the losses, or approximately the value of the resistor alone. To determine actual losses, it's necessary to apply a voltage across the tank and solve for the power dissipated in the resistor. The power dissipated as heat in this resistor is the loss presented by the tank. It should be clear that the losses encountered are inversely proportional to the tank's impedance. If this impedance is high, the loss will be low. If Q can be reduced without decreasing the value of the resistor representing the losses, the performance in multiband antenna applications will be enhanced.

This results from using the single-element trap described and is supported by data collected on four 15-meter traps. Trap A was a commercially manufactured unit; B is the single-element trap built as I have described; C, similar to trap A, is my first attempt at a compact, low-cost design; D was a K9CZB[1]-style trap. The data as measured on an HP-4815A:

trap style	inductor	capacitor	impedance at resonance (kilohms)	Q
A	1.7 inch (4.3 cm) dia. 14 AWG (1.6 mm) wire	concentric tubing	40	142
B	1.7 inch (4.3 cm) dia. RG-58U	RG-58/U coax cable	41	56
C	1.7 inch (4.3 cm) dia. 14 AWG (1.6 mm) wire	concentric tubing	27.5	75
D	1.7 inch (4.3 cm) dia. 14 AWG (1.6 mm) wire	RG-8/U coax stub	54	126

When compared with the commercial design, the single-element trap has approximately the same impedance at resonance (equal losses) but nearly three times the bandwidth. This means the accuracy and stability can be three times worse and still achieve equal results. The traps I use were built in a hurry and are resonant out of band. There was no detectable interaction during adjustment, and the performance of the antenna has been excellent on all bands.

pros and cons

A brief review of the relative advantages and dis-

advantages of trap antennas compared with separate antennas per band is offered here:

advantages:

1. Multiband operation achieved with a good match on all bands.

2. Automatic bandswitching.

3. Antenna length reduced.

4. No compromise operation on highest band(s) since a full-size antenna is employed there.

5. Lower cost than separate antennas.

disadvantages:

1. Lower radiation efficiency due to trap losses on lower bands.

2. Narrowing of bandwidth due to the inductive loading presented by the traps.

3. Loss of second-harmonic rejection *if* bands are so related.

The first two disadvantages, though not severe, are the compromise that is made in any trapped antenna design. This is also true of the third, but this compromise deserves more comment. Single-band antennas provide second-harmonic rejection due to mismatch losses, and in a simple test nearly 20 dB of rejection was achieved. This compromise affects all of us, not just the user of the antenna, and to keep interference minimal, antenna matching systems are recommended. If a matching system is not used, careful tuning of the transmitter, and application of U.S. Regulations Part 97.67b[2] will go a long way in maintaining peace and friendship within the Amateur fraternity and among other services as well.

construction

Table 1 provides the dimensions for traps below 30 MHz. These dimensions assume RG-58/U and 1.25 inches (3.2 cm) PVC stock are the materials used. Form lengths given permit 1 inch (2.5 cm) to extend beyond each side of the coiled coax. This facilitates using the form as a support for each antenna section and can be adjusted to suit personal preferences. All traps must be close wound and should be as tight as possible to ensure mechanical stability. The coax lengths permit 3 inches (7.6 cm) to extend beyond each side of the coil, permitting antenna-section splicing and the wiring of the trap itself.

With the form and coax cut as indicated in table 1, assembly can begin. An 0.2-inch (0.5-cm) drill was selected to allow a snug fit for the coax.

1. Begin construction of the trap by drilling one hole approximately 1 inch (2.5 cm) from the end of the form.

2. Strip 3 inches (7.6 cm) of insulation off one end of the coax, and separate the shield and center conductor.

3. Strip 2 inches (5 cm) of insulation off the center conductor. Insert this end of the coax into the hole drilled in the PVC form until the coax jacket extends into the inside of the form no more than 0.25 inch (0.6 cm).

4. Very tightly wrap the coax around the form the specified number of turns and locate the point where the coiled coax should end. Mark this spot.

5. Move the coax end away, and drill a second hole at the marked location as near as possible to the next turn of the coil without cutting the jacket.

6. Tightly rewrap the coil to take up the slack that may have been introduced, and mark the end of the coax 0.25 inch (0.6 cm) beyond the hole just drilled.

7. With a sharp knife cut approximately half way through the jacket material only, then completely around the coax at this location.

8. In a similar fashion make a cut lengthwise along the cable from the first cut to the end of the coax. Do not remove the jacket material at this point. Again, tightly rewind the coil and insert the prepared end of the coax through the second hole.

9. Pull the coax from the inside of the form until it lies flat at both ends. (Some massaging of the end of the coax where it passes into the form may be required.) The jacket may be easily removed from the coax at this point and shield and center conductor separated.

10. Remove all but about 1 inch (2.5 cm) of insulation from the center conductor. Twist together the center conductor of one side and the shield of the opposite side. This connection should be internal to the coil form and tightly twisted to keep the leads as short as possible.

11. Cut off all but 0.5 inch (1.3 cm) and solder this connection.

12. Drill a hole 0.5 inch (1.3 cm) from each end and on the same side of the form. These holes are used to support the elements when used in a dipole or wire vertical.

13. Wrap a turn or two of the remaining end of the center conductor through the hole on its end of the form, and do likewise with the remaining end of the shield through the opposite hole.

table 1. Dimensions for constructing traps for frequencies between 3.75 and 29 MHz.

F_c (MHz)	form length (inches)	(cm)	coax length (inches)	(cm)	number of turns	effective length (inches)	(cm)
3.750	6.0	15.2	123.06	312.6	19.79	120	305
7.150	4.2	10.7	70.70	179.6	10.94	65	165
10.075	3.6	9.1	53.70	136.4	8.06	48	122
14.175	3.2	8.1	41.47	105.3	6.00	36	92
18.118	3.0	7.6	34.80	88.4	4.87	29	74
21.225	2.8	7.1	31.24	79.3	4.27	26	66
24.940	2.8	7.1	28.09	71.3	3.74	22	56
28.850	2.6	6.6	25.61	65.0	3.32	20	51

The trap is now complete and ready for installation in an antenna. A silicone-base caulk may be used to seal the traps against weather. I chose not to seal mine and they have been in service for more than a year without degradation in performance.

tuning an antenna

The last column in **table 1** provides the effective length of wire in the trap used. This length should be subtracted on all bands where the trap looks like an inductor to provide a reasonable starting length before tuning.

Start with the highest band used and construct a halfwave dipole using the traps for that band as end insulators. Tune the antenna as desired with the traps connected before going any further. Once tuned, any lower band can be added by connecting more wire to the opposite sides of the traps and extending the antenna from this point. Calculate the length of a quarterwave section on the desired lower band, subtract half the length of the dipole just built, and finally subtract the trap's effective length provided in **table 1**. The result is the length of wire required on the opposite ends of the traps.

Adjust the added sections only to tune the antenna so as not to affect the higher-band antenna that you have already tuned. Traps may be used as the end insulators for this new lower band, and another band (lower still) can be added using the same procedure. When completed, recheck VSWR on all bands. There should be little or no difference from where they were initially tuned.

test data

Fig. 4A is the antenna configuration I chose and is a combination of horizontal trapped dipoles. This provides five-band coverage with optimum bandwidth while remaining a simple construction task. A slight interaction was detected on 10 meters when 15 meters was added (the 10-meter center increased about 200 kHz). This was caused by the connection of the combined dipoles; not by the traps. **Fig. 5** shows the VSWR curves of this antenna. The VSWR of an antenna built as shown in **fig. 4B** is plotted in dashed lines to illustrate the loss of bandwidth by using this approach.

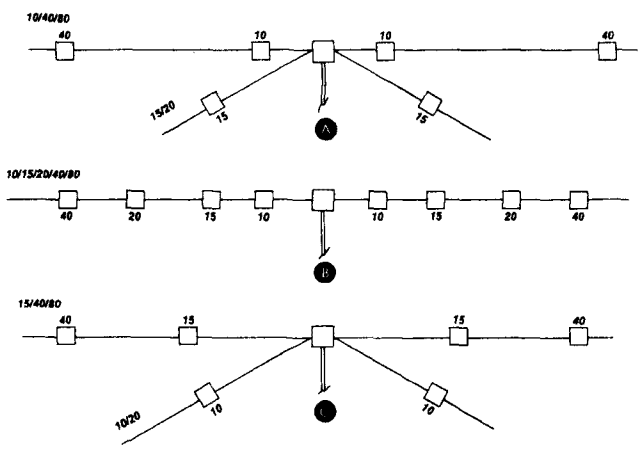


fig. 4. Trap antenna designs. Configuration in use by the author is a combination of horizontal trapped dipoles (A). Single dipole trapped antenna has narrow bandwidth (B). Recommended optimum multiband dipole is shown in C.

Fig. 4C is an alternative approach that has not been verified but is included as an improvement suggestion to reduce the VSWR observed on 15 meters. My assumption here is that the 40-meter and 15-meter dipoles are at or near resonance on 15 meters, thus reducing the feedline impedance by a factor of 2; hence a 2:1 VSWR. I will have verified this assumption as this article goes into print, so watch the letters to the editor for a report of my findings.

Fig. 6 illustrates the impedance bandwidth gained by the wiring technique described, which uses the coupling properties of the coaxial cable.

calculator program

In the interest of expanding the single-element trap applications into areas other than antennas, and accommodating those who have suitable materials other than those that have been described, I can provide a TI-58/59 calculator program that computes the number of tight-wound turns required for a given resonant frequency when the physical properties of the desired materials are specified. In addition, I have described in detail the mathematical derivation of the trap and have provided a step-by-step procedure for building and tuning the antennas described in this article. For copies, send an SASE to the author with a check or money order for $1.50 to cover photo-copy fees. TI-59 owners providing a blank magnetic card will receive a recorded copy of the program.

conclusion

The purpose of, requirements for, and effects of using traps have been explored and supported by comparative test data. In addition, a trap design has been presented that is extremely simple to build (a pair of traps can be built in less than half an hour), costs less than half a dollar per band, and by design requires no tuning. With nothing more than an SWR meter and your transmitter for test equipment, you can have an antenna performing on 80 through 10 meters in a single afternoon.

I hope I have been successful in my attempt to unveil the secrets of antenna traps and instill confidence in those who heretofore have been hesitant, puzzled, or otherwise afraid to pursue trap antenna designs.

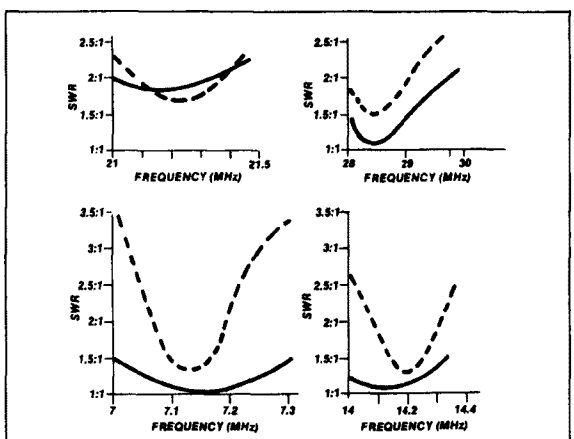


fig. 5. SWR plots of antennas in figs. 4A and 4B (dashed lines) illustrating effects of traps on antenna bandwidth.

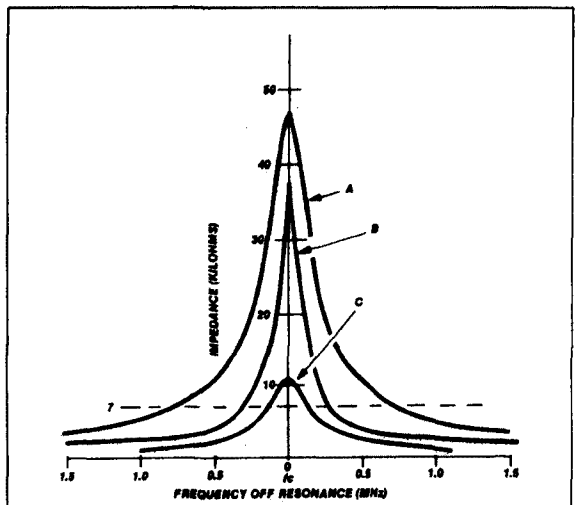


fig. 6. Comparison of relative rejection of 15-meter traps. A represents the single-element trap connected as described in the text. B represents the commercial trap of conventional design that was evaluated by the author. C represents the single-element trap's rejection if improperly connected as discussed in the text. Note the 7 kilohm bandwidth improvement over the conventional design. The rejection is plotted versus frequency away from resonance (f_c).

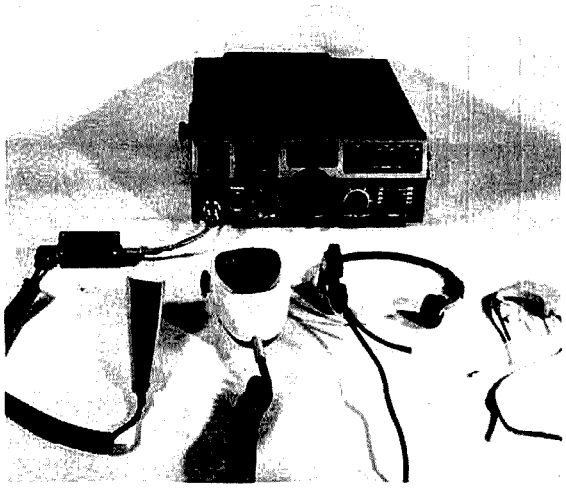
acknowledgments

At this point I would like to thank Joe Williams, N2GU, for his editorial and moral support, and Ray Avery, WA2RRS, for the use of his grid-dip oscillator and his support during testing and evaluation of my trap antennas for harmonic radiation. i would also like to thank Ed Lancki, N2BHD, for the use of his commercial antenna traps in my evaluation.

references

1. Gary E. Myers, "A Two-Band Half Sloper Antenna," *QST*, June, 1980, page 32.
2. *The Radio Amateur's License Manual*, 71st edition, ARRL, April, 1974, page 98.

ham radio



Current-source adapter allows Amateur transceivers to use simulated-carbon microphones such as (left to right) Telex aircraft microphone, Motorola mobile microphone, Pacific Plantronics MS-50 and *StarSet* headsets.

using simulated carbon microphones with Amateur transmitters

Simulated carbon microphones have several advantages over carbon microphones — all you need is an adapter

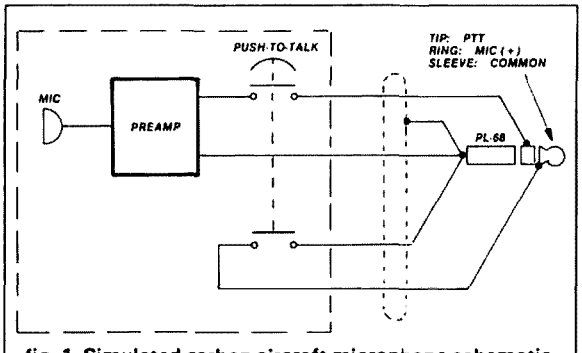


fig. 1. Simulated carbon aircraft microphone schematic showing standard plug connections. Most aircraft microphones have DPST push-to-talk switches, so that multiple microphones can be connected without mutual interference.

Carbon microphones, previously standard in aircraft (**fig. 1**) and many other mobile radios, have been largely replaced by improved types that simulate the electrical characteristics of carbon microphones. Hamfests abound with bargains on high-quality "simulated-carbon" microphones that are sturdily constructed and often include noise-cancelling features. They don't work with most commercially made Amateur equipment, but the required adapter is very simple. (Do not confuse simulated-carbon microphones with the "power microphones" used by CBers.)

The carbon microphone is a variable resistor that changes resistance when sound energy compacts the carbon particles inside it. Unlike dynamic and crystal microphones, which generate their own tiny voltages in response to sound, carbon microphones must be connected to an external source of current to produce an electrical signal. Carbon microphones are rugged, inexpensive, and produce high-level audio signals, but they are no longer popular because of their poor audio-reproduction qualities.

The simulated-carbon microphone contains a dynamic or electret element plus a preamplifier,

By Frank S. Reid, W9MKV, 3243 N. Louden Road, Bloomington, Indiana 47401

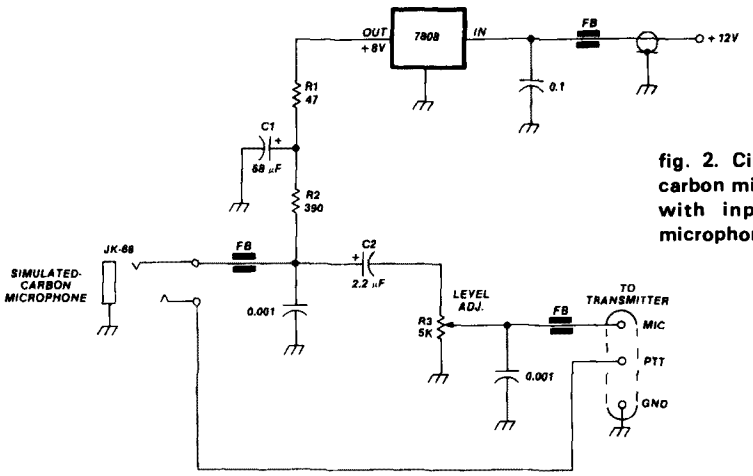


fig. 2. Circuit to supply bias current to simulated-carbon microphones, and couple audio to transmitters with inputs designed for dynamic or crystal microphones.

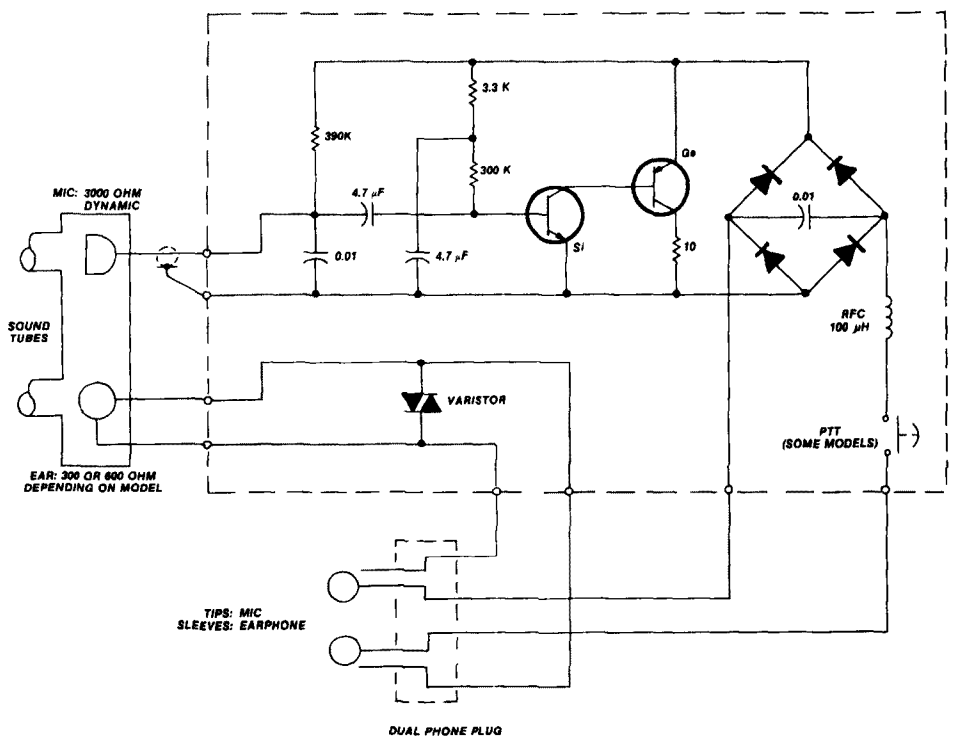


fig. 3A. Schematic of Pacific Plantronics MS-50 headset, telephone switchboard model. Diodes ensure proper polarity to preamp regardless of how plug is inserted but may detect rf, causing feedback.

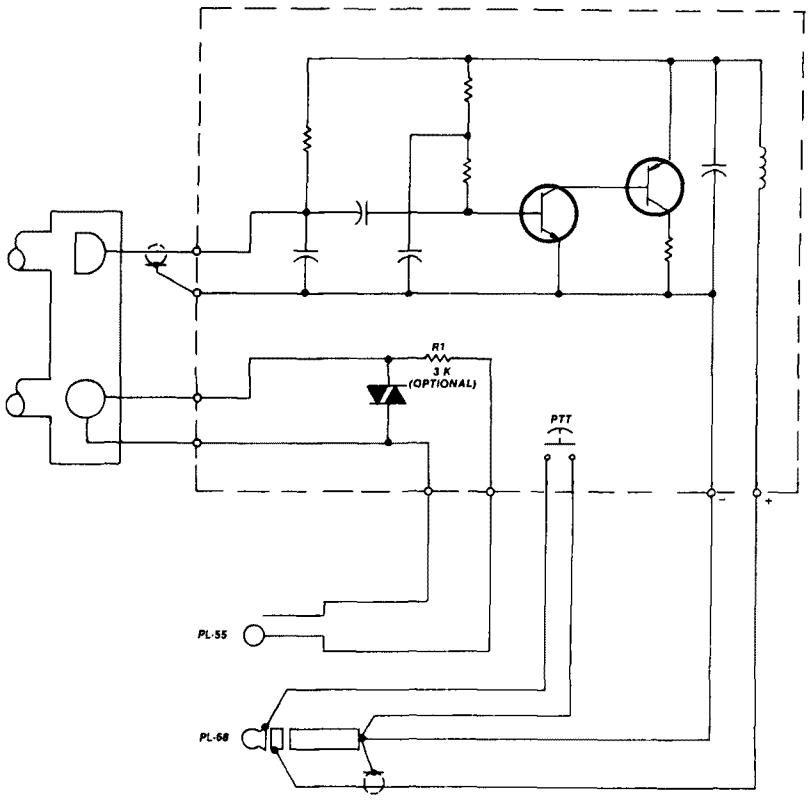


fig. 3B. The same circuit as in (A), modified to prevent rf feedback: diodes have bean removed and shielded cable added. *R1* can be added as an attenuator to equalize earphone and speaker levels.

which is powered by dc microphone-bias current supplied by the transmitter. The preamplifier modulates the bias current, producing an audio signal. The preamplifier is sometimes inside a sealed unit with the microphone element, or may be on a separate circuit board.

adapter circuit

Transmitters designed for carbon microphones may supply anywhere from 10 mA to 60 mA of microphone current. Most simulated-carbon microphones will work properly over this entire range of currents. **Fig. 2** shows a circuit for supplying microphone bias current. R1 and C1 form a decoupling network. R1 and R2 determine the microphone current. C2 blocks dc and couples audio to output level-control pot R3.

construction

If the adapter is built in a small shielded box, you can transfer it among several rigs. Microphone circuits pick up rf interference easily, so use good construction practice in shielding and bypassing. Shield

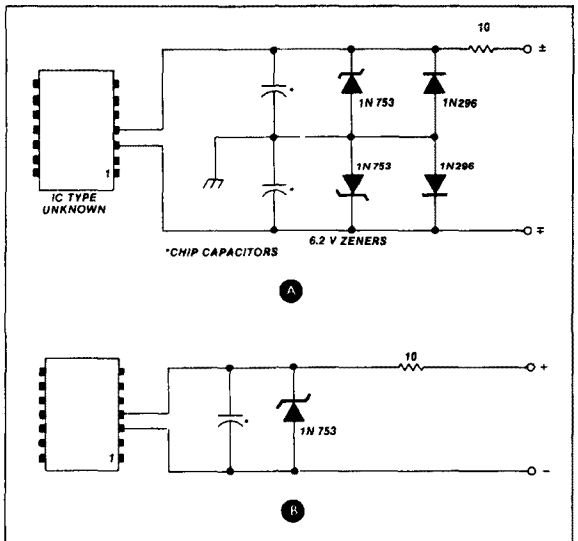


fig. 4A. Partial schematic of Plantronics *StarSet* preamplifier (telephone model), showing zener diodes in current-steering network.
fig. 4B. *StarSet* preamplifier modified for radio use.

the wire to the external power supply, but ground only one end of the shield. Ground the adapter circuit *only* at the transmitter microphone connector, or ground-loop current may cause hum in the output.

The adapter components may be mounted inside the transmitter if you don't mind modifying your equipment. The voltage-regulator IC can be eliminated if you can find a well-regulated source of 8 to 11 volts inside the rig.

adjustment

The level control must be set to provide the proper amount of audio to the transmitter input. To set the level, I connect an oscilloscope to the transmitter input terminals and observe the output of the rig's original microphone while talking normally, then substitute the adapter and adjust the pot until the signal reaches the same peak value. On an SSB transmitter with output meter, the meter can be used to compare microphones. You should then use an oscilloscope to inspect the rf output waveform for proper modulation.

converting surplus headsets

Headsets are great for contest and mobile operation, but most are bulky, uncomfortable, and can dangerously restrict a driver's hearing. The tiny Pacific Plantronics headsets overcome these limitations but cost up to $200 from suppliers of aircraft equipment. Slightly different models designed for telephone switchboard use are often available at hamfests and surplus outlets. Their preamplifiers contain current-steering diodes so that they will work properly with any bias supply polarity (**figs. 3A, 4A**). They usually work well with no modification, but they may pick up rf interference if used with high-power stations. To prevent rf feedback problems, remove diodes, rewiring as shown in **figs. 3B** and **4B**. Replace the telephone cord with a multi-conductor replacement-type microphone cable having at least one shielded wire inside. Add your own push-to-talk switch if necessary. With diodes removed, you must determine proper polarity and use some type of polarized connector. The standard aircraft microphone plug (military designation PL-68) is wired as shown in **fig. 1**. It looks like a three-conductor stereo phone plug but is smaller in diameter. Surplus PL-68s are plentiful at hamfests (scouring powder will polish the brass nicely).

The circuit of **fig. 2** is not recommended for small hand-held portables, where the microphone current would contribute significantly to battery drain. The 3000-ohm dynamic microphone element in most models of Plantronics headsets can drive many rigs directly, or through a small matching transformer.

ham radio

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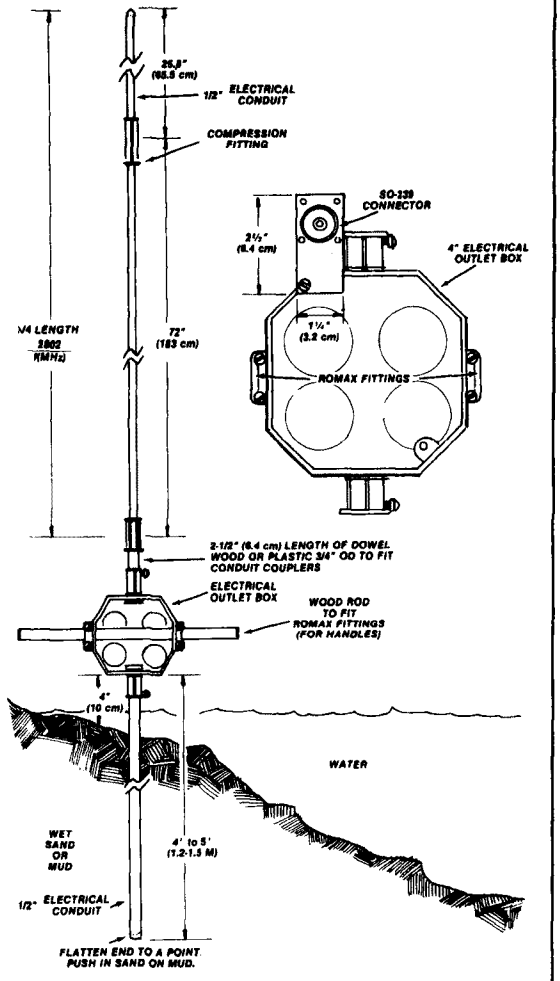


fig. 1. Ugly is beautiful. Construction details of the portable antenna. Design is based on a resonant frequency of 28.7 MHz.

Antenna experts have a favorite saying: "Vertical antennas radiate equally poorly in all directions." There's some truth in this statement if the ground system is inefficient. However, if you live within a reasonable coax-cable length of a lake or any water more than a wavelength (no pun intended) wide, the vertical antenna described here may be worth a try. It's a low-cost system and can be made of readily available materials. You probably have them in your garage or basement.

background

My wife and I have an RV (recreational vehicle). This vacation season we set up the RV right by a lake in Sussex county, Delaware. I had my Ten-Tec OMNI-D and, as usual, a 40-meter dipole antenna to string up in the trees for a little R & R. Things went well.

One day I thought, "Hey, some 10-meter operation would be fun." But that required another antenna. Then it hit me: that lake is nature's ground plane. All I have to do is get 8 feet (2.4 meters) of something to stand *up on* or *in* it. Back at home in the garage I had some 1/2-inch thin-wall conduit and some electrical outlet boxes. What could be better!

the portable vertical

Take a look at fig. 1. Ugly, right? But it works and works well. And it doesn't cost a bundle. All you need is the material listed in table 1. Collect this stuff, get out your electric drill motor, and heat up your soldering iron. Open a can of beer and you're ready to start.

construction

1. Mount set screw connectors to the top and bottom of the electrical outlet box (square or hexagonal).

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2. Mount two Romax fittings to the sides of the outlet box.

3. Insert a 1/2-inch (12.5-mm) diameter wooden dowel 12 to 18 inches long into the Romax fittings; tighten securely. These are handles for screwing the assembly into the ground.

4. Secure a coax connector (SO-239) to a small piece of aluminum plate.

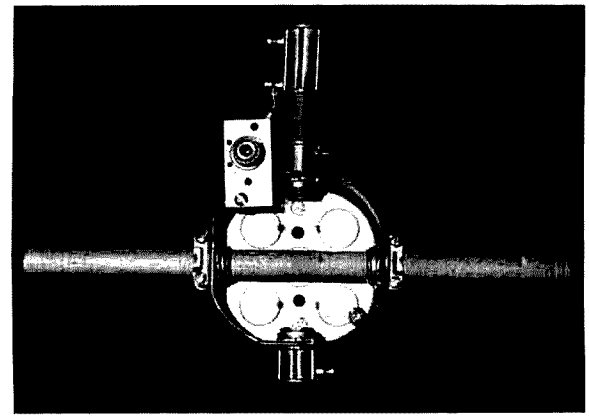
5. Drill a clearance hole (3/16-inch or 5-mm) in the aluminum plate 1/4 inch (6.5 mm) from lower left corner (in and up). This allows the coax-fitting mounting plate to use the existing screw hole that would normally be used for the cover plate and makes the ground connection.

6. Cut a 2-1/2 inch (6.4-cm) wood or plastic dowel (3/4 inch or 19 mm O.D.). This is the center insulator. Insert it into the top screw connector on the outlet box and secure with a setscrew.

7. Install a 1/2-inch setscrew coupler on top of the dowel.

8. Solder one end of a 2-inch (5-cm) piece of No. 12 (2.1 mm) wire to the center contact on the SO-239 coax connector.

9. Install a closed-eye solder lug on the other end of the wire.



Details of the electrical outlet box, which forms the base of the 10-meter antenna. Wooden dowels are handles for working the bottom piece of conduit (not shown) into mud or sand.

10. Bend the lug to pick up the bottom screw on the setscrew coupler. Draw it down to make contact with solder lug and secure the coupler onto the center insulator.

11. Select one of the 10-foot (3-meter) pieces of conduit and, using a pipe cutter, cut a piece 72 inches (183 cm) long. (This length was chosen to make carrying in the trunk of the car easier.)

table 1. Materials list for the junkbox portable antenna. (Note that metric equivalents are not given for standard electrical conduit and fixtures.)

materials	quantity	use
4-inch outlet box (no cover)	1	to hold antenna and handle
1/2-inch setscrew connector	2	1 for ground 1 to hold vertical insulator
Romax connector	2	to hold handle
wood or metal rod to fit Romax connector, 12-18 inches (30-46 cm)	1	to make handle
SO-239 coax connector	1	for coax cable
small piece of aluminum plate	1	to hold SO-239 connector
2 1/2-inch (6.4 cm) wood or plastic dowel 3/4-inch (2 cm) O.D. to fit 1/2-inch conduit coupler	1	insulator for antenna
1/2-inch setscrew coupler	1	to connect insulator to vertical element
2-inch (5-cm) length of No. 12 (2.1-mm) wire	1	center of coax connector to top of conduit coupler
solder lugs and washers, closed-eye, to fit screws on couplers	–	to make connections
10-foot (3-meter) length 1/2-inch electrical conduit (thin wall)	2	1 for vertical element 1 to push in mud/sand
1/2-inch compression fitting	1	to hold vertical elements together

Note: formula: 2808/f in MHz = length of 1/4-wave element in inches (2.54 cm/inch). Materials are for antenna resonant at 28.7 MHz.

12. From the remaining length of this conduit, cut a piece 25.8 inches (65.5 cm) long.

13. Now, from the second 10-foot (3-meter) piece of conduit, cut a piece about 5 feet (1.5 meters) long. Flatten one end to make a point (so it can be pushed into sand or mud). Set it aside.

on-site assembly

1. Join the 72-inch (183 cm) and the 25.8-inch (65.5 cm) conduit with a 1/2-inch compression coupler. Set all this aside. This is the vertical element.

2. Attach the 5-foot (1.5-meter) piece to the bottom set screw connector on the outlet box.

3. Push the outlet box with its 5-foot (1.5-meter) piece of conduit into mud or wet sand until it's approximately 4 inches (10 cm) out of water.

4. Put the vertical element, previously assembled in step 1 above, into the top set screw coupler in the outlet box; tighten.

5. Connect 50-ohm coax to SO-239 and to transmitter.

6. Start calling CQ.

results

They were great! First contact: VE6CGN in Alberta, Canada. Then HP1XWA, in Panama. The antenna was doing fine. The SWR was 1.2:1 over the phone band. I did not use a tuner at all and ran full output from the OMNI D.

afterthought

Late in the evening I remembered I had a piece of metal tape from a broken windup rule. Why not? It turned out that, you guessed it, 35 feet (10.6 meters) was left with the hook end. So I cut it at 32 feet, 4 inches (9.9 meters), drilled a hole in the end (using light pressure, because thin metal will split, then backed it up with wood). I installed two solder lugs (closed-eye) back-to-back. Then I sanded the paint off the end of the rule and attached a solder lug with a machine screw and nut. Next, I put a piece of nylon fish line over a tree limb at the edge of the lake and pulled up the 40-meter vertical. The end with the solder lugs was put under the screw in the setscrew coupler, *and* the 10-meter element was removed.

results

Again, results were great! The VSWR was 1.4:1 over the phone band; plus it also worked on 15 meters.

So give it a try; you'll like it! I have some experiments going on with garden hose — I'll keep you informed.

ham radio

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operation upgrade:

part 2

The second part in a continuing series designed to help you get that higher ticket

Last month, in the first of our series of articles, we explained some of the topics identified by the FCC as being in the tests for Amateur licenses. That article explained in basic terms such fundamental things as voltage, current, resistance, Ohm's law, inductors, capacitors, and power, and how they are interrelated in some relatively simple dc circuits.

This month we will try out some ac circuit theory involving these same concepts. This is an area of electricity that many people seem to shy away from because of its angles, tangents, cosines, and so forth. But much of this information is quite important if you want to understand how radio circuits actually work. Our engineering friends may turn up their noses at this down-to-earth treatment of a highly complex field of theory, but let's plunge in anyway.

inductive reactance and impedance

Our discussions about the inductance of a coil of wire indicated that a counter EMF (CEMF) develops whenever current changes value in an inductor. The CEMF always tries to oppose whatever the current wants to do. If the current tries to increase, the CEMF tries to prevent it. If the current tries to decrease, the CEMF tries to increase it. The resulting opposing, or resisting, effect produced by the CEMF is properly called inductive reactance, symbolized by X_L (X indicates reactance, L indicates inductance). The unit of measurement of X_L is the ohm, usually shown by either a capital Greek letter omega, Ω (the same as is used for resistance), or by a lower-case omega, ω. We will use Ω for purely resistive values, and ω for values having reactance. This should help prevent confusion when we are talking about the various forms of oppositions in electricity.

The formula to determine how much opposing effect that inductive reactance has in ohms is:

$$X_L = 2\pi fL$$

By Robert Shrader, W6BNB, 11911 Barnett Valley Road, Sebastopol, California 95472

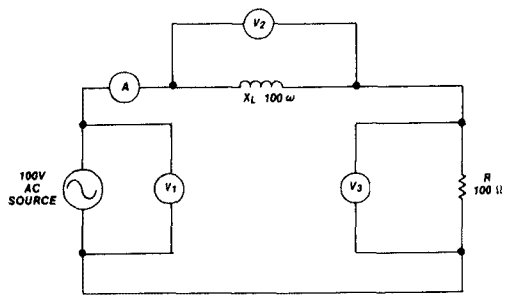


fig. 1. Ac circuit with inductive reactance and resistance in series as the load.

where X_L = inductive reactance in ohms, ω

π = 3.1416

f = frequency in hertz, Hz

L = inductance in henrys, H

As an example, the inductive reactance of a 2.5-henry coil to 1000-Hz ac is $X_L = 2\pi fL$, or (6.28)(1000)(2.5), or 15,500 ω. Can you see from this formula that the same inductor (coil) will have twice the reactance at twice the frequency because X_L is directly proportional to f? A resistor, on the other hand, has the same resistance value regardless of the frequency of the ac, or even if dc is used with it.

In a resistor, the current that flows through it varies in phase (in step) with any voltage change occurring across the resistor. If the voltage increases across a resistor, the current increases proportionally. In a coil, which has inductive reactance, the voltage of an alternating current passing through the inductor can, of course, be plotted (with respect to time) as a sine curve. The current passing through the coil can also be plotted (with respect to time) as a sine curve. It will be found that, if the two curves are compared on the same graph, the sine curve representing the current will lag 90 degrees behind that representing the voltage. We can consider this to be caused by the building up of the magnetic field around the coil, and by the counter-EMF developed in the coil.

Let's see what we can find out about the ac circuit shown in **fig. 1**. An ac generator or alternator (the circle with a one-cycle sine wave in it) feeds a circuit composed of X_L in series with an R. Since this is a series circuit, the same current flows in all parts of the circuit, so only one ammeter is needed. The three voltmeters measure all possible voltages in the circuit.

If the source of EMF had been shown as a battery or a dc generator, from Ohm's law ($I = E/R$) the current in the circuit would have been $I = E/R$, or 100/100, or 1 amp. In this case, with dc flowing, X_L would have no opposing effect, and the load in the circuit would be the resistor alone. What do you think voltmeter V_1 would read? _____ V_2? _____ V_3? _____

V_1 would read the 100-volt source voltage. With dc being used, V_2 is measuring across zero ohms resistance (the coil is assumed to have no R value) and therefore would read zero volts. And V_3 would have to read the 100 volts of the source. What power would the circuit be dissipating? (Remember, the basic power formula is $P = EI$.) Work it out for yourself. P = _____

This brings up an important point. Since in this case, the coil has dc flowing through it, there is no varying magnetic field around the coil and no CEMF is being developed. There is energy in the coil's magnetic field, but it is static (meaning stationary). Any energy stored in the static magnetic field will be returned to the circuit when the current is turned off. The only thing dissipating energy (heat in this case) is the resistor. It is dissipating $P = EI$, or 100(1), or 100 watts of heat.

Now let's return to the illustration as it is shown, with the source 100 Vac. The load is a 100 ω X_L in series with a 100 Ω R, right? So the total opposition to the ac is going to be *100 + 100 = 200 ohms* — right? WRONG! It will be only 141.4 ω. Where did *that* value come from? Let's see.

Resistance is a true and constant opposition under essentially any conditions. We can draw a horizontal vector arrow representing 100 Ω resistance and label it R, as shown in **fig. 2**. The reactance of the coil does not oppose the flow of current by 180 degrees as the resistance does, but it opposes the current at *exactly 90 degrees*. Therefore, we draw the opposi-

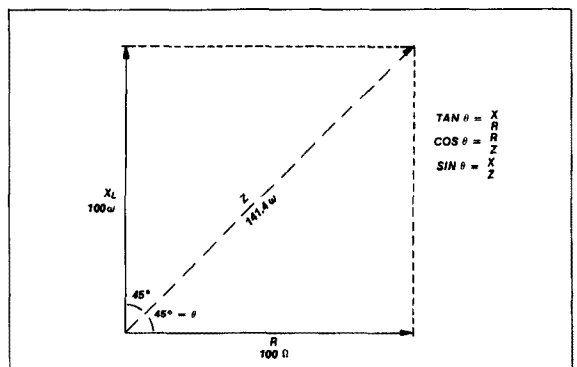


fig. 2. Developing an R, X_L, and Z triangle from R, X_L, and Z vectors, and three useful trigonometric formulas.

tion of the X_L at an angle of 90 degrees from the resistance, at right angles, or upward. By drawing dotted lines parallel to both the R and X_L vector arrows, the resultant opposition of R plus X_L will be that shown by the dashed vector arrow labeled Z. This resultant opposition is called the impedance, Z, of the circuit, and has a value of 141.4 ω. (We use ω for ohms because part of the opposition is reactive.) How did we get the 141.4 Ω value? Well, you could lay out the vector arrows to scale on a piece of graph paper and measure the impedance value with a metric ruler, which is probably the simplest but least accurate way of doing it.

A second method is to use the Pythagorean theorem for right-angled triangles, which says that the square of the Z side of this right-angled triangle (made up of the R, the Z, and the dotted X_L side) is equal to the sum of the squares of the R and X_L sides. As a formula this is expressed as:

$$Z^2 = R^2 + X_L{}^2$$

Or, in our particular circuit:

$$Z^2 = 100^2 + 100^2$$

$$Z^2 = 10{,}000 + 10{,}000$$

Solving for Z (taking the square root of *both sides of* the equation),

$$Z^2 = 20{,}000$$

$$Z = 141.4$$

The complete formula to find impedance is therefore:

$$Z = \sqrt{R^2 + X_L{}^2}$$

Here is a problem to try. The answer is at the end of the article. **Problem 1**: What would be the impedance of a series ac circuit having $R = 80\Omega$, $X_L = 40\omega$? Answer _____.

A third way you might find the impedance is to first determine the phase angle (how many degrees the I lags or leads the E in a reactive circuit). The phase angle, usually shown as the Greek letter theta, or Θ, is the angle developed at the meeting point of sides R and Z. In our circuit, with $R = 100$ and $X = 100$, and being at right angles or 90 degrees, the R-Z angle must be half of 90 degrees, or 45 degrees. Thus, the phase angle, or Θ, for this circuit is 45 degrees.

However, when R and X are not equal, we must find Θ some other way. One way is to use a protractor to measure the angle if you graph the problem. The tangent (tan) ratio of our triangle, which is the ratio of the X side to the R side, or X/R, can be used to find Θ very accurately. Tan Θ in our case is X/R, or 100/100, or 1.0000. Refer to **table 1**, which shows a few selected tangent and cosine ratio values and their angles. By searching through the table you will find that, when $tan\ \Theta = 1.0000$, $\Theta = 45$ *degrees*. (With one type of electronic calculator, enter the tangent value of 1.000, then punch in ARC, then TAN, and it should show 45 degrees. However, your calculator may use a different method of determining tangents.)

Now that we know the phase angle (how many degrees the current lags behind the voltage in an inductive circuit), what about the impedance value? Whereas the tangent ratio of the RXZ triangle is X/R, the cosine ratio is R/Z. This cosine ratio is handy for us because it includes not only the R and Θ values, which we know, but also the Z value, which we want to know. Using the cosine ratio we can determine the Z value with the information we now have. The cosine (cos) formula is

$$cos\ \Theta = \frac{R}{Z} \quad \text{or} \quad cos\ 45\ degrees = \frac{R}{Z}$$

From the table you can find that cos 45 degrees is equal to 0.707. By plugging the known information into the cos formula we get

$$cos\ \Theta = \frac{R}{Z}$$

$$0.707 = \frac{100}{Z}$$

If you have not been doing much math lately, let's try solving for the unknown value (Z) of this equation by using the cheap and dirty method of cross multiplying and then dividing out the unwanted to find what

table 1. Some trigonometric function values.

angle (degrees)	tan	cos
0	0.000	1.000
5	0.0875	0.9962
10	0.1763	0.9848
15	0.2678	0.9659
20	0.3640	0.9397
25	0.4663	0.9063
30	0.5774	0.8660
36.87	0.7500	0.8000
39.8	0.8333	0.7682
40	0.8391	0.7660
45	1.0000	0.7071
50	1.1918	0.6428
55	1.4281	0.5736
60	1.7321	0.5000
65	2.1445	0.4226
70	2.7475	0.3420
75	3.7321	0.2588
80	5.6713	0.1737
85	11.430	0.0872
89	57.290	0.0175
90	Infinite	0.0000

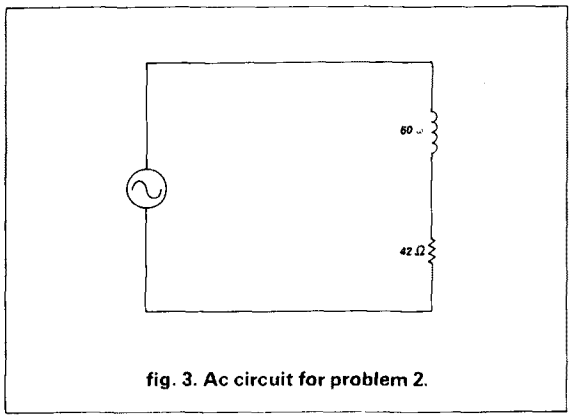


fig. 3. Ac circuit for problem 2.

Z equals. In this case

$$\frac{0.707}{1} = \frac{100}{Z}$$

Now, by cross multiplying top and bottom values we get the relatively straightforward equation

$$0.707(Z) = 100(1) \quad \text{or} \quad 0.707Z = 100$$

To find the Z value, divide out from both sides of the equation the unwanted information on the left side, giving us

$$\frac{0.707Z}{0.707} = \frac{100}{0.707}$$

This leaves

$$Z = \frac{100}{0.707}$$

$$Z = 141.4\,\omega$$

Incidentally, the sine $\Theta = X/Z$ formula shown in **fig. 2** could also have been used to solve for Z if sine tables are used. These three trigonometry formulas, tangent, cosine, and sine (sin), are very handy in ac circuit computations.

How about trying to solve an impedance problem on your own? **Problem 2:** What is the Z of the series circuit shown in **fig. 3**? $Tan\ \Theta =$ _____ $Angle\ \Theta =$ _____ $Cos\ \Theta =$ _____ $Z =$ _____.

Of course, it is possible to compute ac circuits of this type if only the inductance in henrys and the resistance are given. You would have to first convert the inductance value to inductive reactance. The frequency of the ac would also have to be known to find the X_L value. You would be surprised what you can do with these ac circuits if you list what values you know, and then consider filling in the information into one or more of the formulas that you know. You can find voltage-drops across components (with Ohm's law), currents, phase angles, impedances, reactances, power values, and so on, provided you understand the relatively few facts we have discussed so far. This doesn't mean that ac circuits can't become extremely complicated. They can!

capacitive reactance and impedance

In **fig. 4**, a series ac circuit is shown using a capacitor in place of the inductor of **fig. 1**. If the capacitor has very little capacitance, only a small current can be driven back and forth through the resistor with a given ac voltage. If the capacitor is larger it can be charged and discharged with more electrons and the ac charging current that would now flow through the resistor will increase. Thus a capacitor must have both an ac conducting and an opposing effect, or *reactance*. Capacitive reactance, X_C, opposes ac somewhat like resistance does, but it is not the same as resistance.

To determine just how much opposing effect, in ohms, a capacitor will have in an ac circuit, use the formula

$$X_C = \frac{1}{2\pi fC}$$

where X_C = capacitive reactance in ohms, ω

π = 3.1416

f = frequency in hertz, Hz

C = capacitance in farads, F

As an example, what reactance does a capacitor of 0.01-μF have to a 7 MHz ac?

$$X_C = \frac{1}{2\pi fC}$$

$$X_C = \frac{1}{6.28(7,000,000)(0.000\,000\,01)}$$

$$X_C = \frac{1}{0.4396}$$

$$X_C = 2.27\,\omega$$

Can you see that a 0.01-μF capacitor acts as a pretty good conductor of ac at 7 MHz, which is one edge of the 40-meter Amateur band? A 0.001-μF capacitor would have only 22.7 ω. Thus, to couple rf ac from one circuit to another, capacitors make very good coupling devices. Capacitors may couple ac, but they will stop dc current completely. However, if the dc is varying, a capacitor will pass the varying part, or ac component, and block the dc component. Note that the same capacitor used on the 3.5-MHz Amateur band will have twice the reactance that it would have at 7 MHz, because X_C is inversely proportional to frequency.

In a resistor the current through it and the voltage-drop across it are always in phase. As mentioned pre-

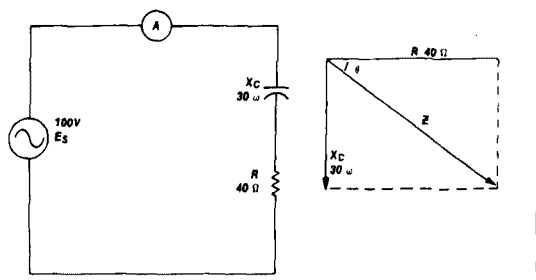


fig. 4. Series type capacitive and resistive ac circuit and its vector diagram.

viously, an inductor always has its current lagging behind the circuit voltage by 90 degrees. A capacitor always has its current *leading* the circuit voltage by 90 degrees. These reactive phase shifts are important in the operation of ac circuits. For one thing, it is possible to add capacitance to an inductive-resistive circuit to reduce a phase lag of the current caused by the inductance.

What would be the phase angle, the impedance, the current, and the voltage drops in the fig. 4 circuit? We can apply exactly the same computing ideas to a capacitively reactive circuit as we did with the inductively reactive circuit before. The phase angle (the number of degrees by which the current leads the voltage) may be found by $tan\ \Theta = X/R$, or in this case $tan\ \Theta = 30/40$, or 0.750. From the table, the angle Θ is 36.87 degrees.

Knowing $\Theta = 36.87\ degrees$, then $cos\ \Theta = R/Z$, and by cross multiplying, $Z = R/cos\ \Theta$. In this case, from the table of cosine values, $cos\ 36.87\ degrees = 0.8000$, or $Z = 40/0.8000$, or $Z = 50\ \omega$.

If $Z = 50\ \omega$ and the effective source voltage, E_s, is 100 volts we can make the dc Ohm's law formulas work for ac circuits by substituting Z for R. Thus, $I = E/Z$, or $E = IZ$, or $Z = E/I$. In our circuit, $I = E/Z$, or 100/50, or 2 amps flows through the capacitor and the resistor. (Actually, electrons do not flow *through* a capacitor, but it charges and discharges through the resistor, allowing current to flow through the resistor and the ac source.)

There is an interesting thing about computing power in ac circuits. If we have a 2-amp current flowing in the **fig. 4** circuit and a source voltage of $E_s = 100\ volts$, then from the power formula $P = EI$ we would expect to have 100(2), or 200 watts being dissipated. But a wattmeter in this circuit would show only 160 watts! The 200 value from a voltmeter and an ammeter is called the reactive power, or the volt-amperes (VA) of the circuit. The true power, that amount of energy actually lost by the circuit, is what the resistor alone is dissipating. (Remember, the reactor does not lose energy. It may store energy, but it returns it all to the circuit when the current is turned off.) The true power can be found by $P = E_T I_T$, or by $P = I_T^2 R$, or by $P = E_T^2/R$. Since we do not know the voltage across the resistor at this time, we can use the formula $P = I^2R$, or 2²(40), or 160 watts. So, for this circuit the reactive power is 200 VA, and the true power is 160 watts. Note that a wattmeter always indicates true power, and that the formula $P = I^2R$ always tell us the true power.

The ratio of true power (P) to volt-amperes (VA) is known as the power factor of the circuit. In our circuit of fig. 4, the power factor (pf) = P/VA, or 160/200, or 0.8000. You can express a pf of 0.8000 as a pf of 80 percent by moving the decimal point over two places and adding the percent sign. You will also find that the power factor is always equal to the cosine of the phase angle ($cos\ \Theta = pf$). For our circuit, the pf is 0.8000, the cosine of Θ is 0.8000, and from the table, $\Theta = 36.87\ degrees$ as determined previously.

In our circuit, if a 2-amp current flows through a 30ω X_C, the voltage-drop across X_C by Ohm's law, but using reactance in place of resistance, is $E = IX_C$, or 2(30), or 60 volts. The voltage-drop across the R will be $E = IR$, or 2(40), or 80 volts. Note that the simple sum of the vector voltages across X_C and R add up to more than the source voltage. That is, $E_{x_c} = 60\ volts$, and $E_T = 80\ volts$, for what appears to be a total of 140 volts. But if we try plotting these two voltages as vectors at right angles as we did with X_C and R, we will find that the resultant vector, which represents the source voltage, will be exactly 100 volts, as it should be.

Suppose we have a circuit with X_L, X_C, and R all in series, as in **fig. 5**. The reactances are graphed as before, X_L upward, X_C downward, and R to the right. Can you see that the 50 ωX_L is cancelling 50 of the 75 ω of X_C, resulting in a total of only 25 ω of effective reactance (capacitive) for the circuit? To determine the impedance of this series circuit we would use the values of 30 Ω of R, and the resultant value of 25 ω of X_C. To check your understanding try **Problem 3**: With $X_C = 25\ \omega$ and $R = 30\ \Omega$, what is tan Θ? _____ Θ? _____ cos Θ? _____ Z? _____ I? _____ E_T? _____ E_x? _____ P? _____ Does I lag or lead? _____

series and parallel circuits

When two resistors are connected in series, as in **fig. 6A**, the total resistance is simply the sum of the two resistors, or $R_t = R_1 + R_2$. But if the two resistors are in parallel as in *B*, they form a better conductor (less resistance) than either one alone. There are

two formulas given which produce the proper total resistance of two parallel resistors. These are

$$R_t = \frac{R_1 R_2}{R_1 + R_2} \text{ and } R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$$

If R_1 is 100 Ω and R_2 is 100 Ω, what will the total resistance be? Try working this out with both formulas and see if you don't come up with 50 Ω in each case. What if there are more than two resistors in parallel? Well, if there are three, then compute two of them in parallel and use this answer to compute the third resistor in parallel. If there are four in parallel compute the first three and use this answer along with the fourth in parallel.

When two inductors are connected in series as in **fig. 6C**, the total inductance in henrys is the simple sum of the two inductors. Similar to resistors, two parallel inductors, as in **D**, can be computed with the same two parallel component formulas, substituting *L*s for *R*s in the formulas.

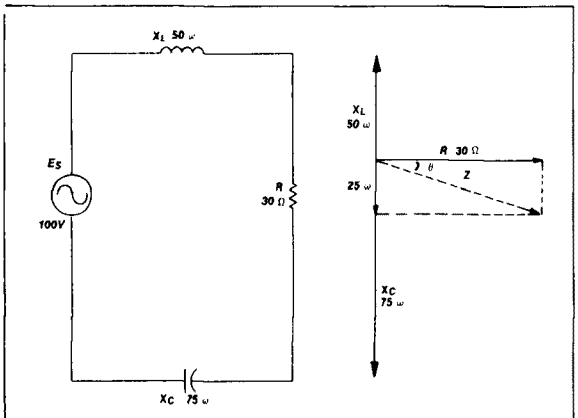


fig. 5. Series X_L, X_C, and R ac circuit and vector graph.

When two capacitors are connected in series, as in **fig. 6E**, between the top of the circuit and bottom there is now a greater dielectric separation than for either capacitor alone, and therefore less capacitance. So we cannot use the simple addition of capacitances, but must use the parallel resistor type formulas for capacitors in series, or

$$C_t = \frac{C_1 C_2}{C_1 + C_2} \text{ or } \frac{1}{\frac{1}{C_1} + \frac{1}{C_2}}$$

When two capacitors are connected in parallel, as in **F**, the total capacitance is the simple sum of the two capacitors, or $C_t = C_1 + C_2$.

In **fig. 7** we have the same circuit configurations but this time the components are labeled in resistance, inductive reactance, and capacitive reac-

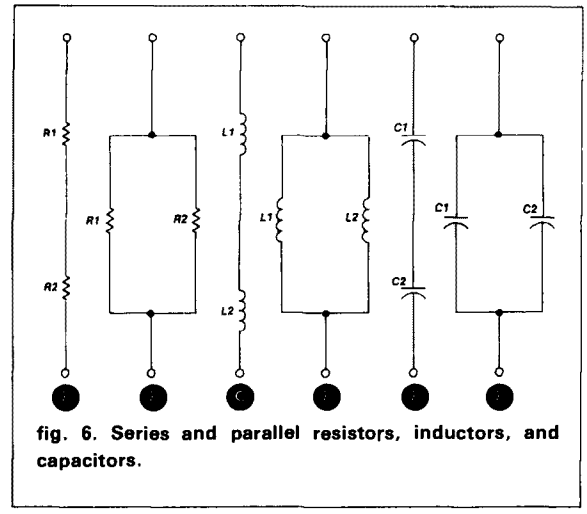


fig. 6. Series and parallel resistors, inductors, and capacitors.

tance. Now, all oppositions, resistance and reactances, if in series, are found by simply adding the component values. Similarly, when in parallel you use the parallel resistance type formulas to determine the total oppositions, substituting *X*s for *R*s.

In **fig. 8A**, the circuit is shown with resistance, inductance, and capacitance values given. To compute the circuit parameters (values) it is necessary to first convert the L value to an X_L value, using the given frequency and the formula $X_L = 2\pi fL$. The capacitance must similarly be converted to X_C by the formula $X_C = 1/2\pi fC$ (using farads, not the μF value that is given). The impedance of such a series RLC circuit is computed as explained in the previous section. In this case the Z value is computed as 200 ΩR and 796 ωX_C minus 314 ωX_L, or as 200 ΩR and 482 ωX_C, or $Z = \sqrt{200^2 + 482^2}$, or 521.8 ω.

The circuit in **fig. 9** shows a resistance and an inductive reactance in parallel. There are a variety of

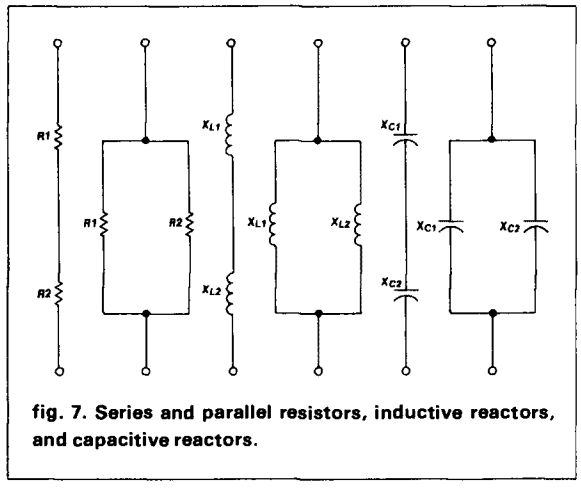


fig. 7. Series and parallel resistors, inductive reactors, and capacitive reactors.

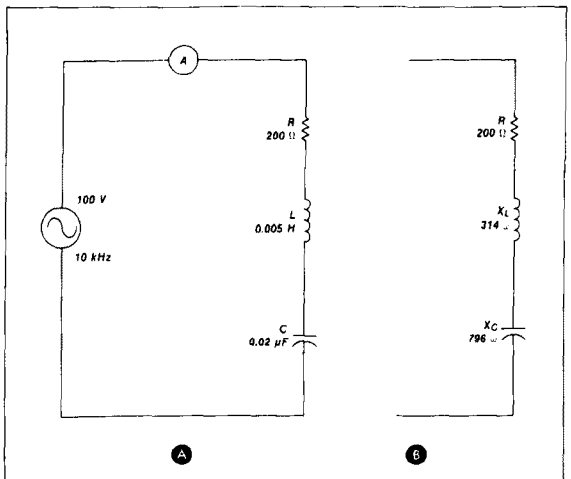


fig. 8. (A) Series RLC circuit must be converted to (B) R, X_L, and X_C values to compute it, using the given frequency.

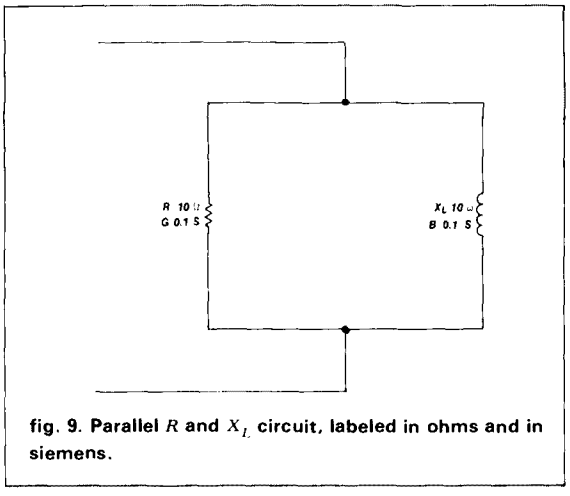


fig. 9. Parallel R and X_L circuit, labeled in ohms and in siemens.

ways of computing the impedance of such a circuit. We will discuss only one of them. We cannot use the series-type impedance formula ($Z = \sqrt{R^2 + X^2}$) unless we use reciprocal values in it. ($1/R$ is the reciprocal of R, called conductance, symbolized G. $1/X$ is the reciprocal of X, called susceptance, B. $1/Z$ is the reciprocal of Z, called admittance, Y.) The unit of measurement of these reciprocal values is either mho (reverse spelling of ohm), or siemen, S. So, to solve a parallel RX circuit as **fig. 9**, the basic formula would be

$$\frac{1}{Z} = \sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X}\right)^2} \quad \text{or} \quad Y = \sqrt{G^2 + B^2}$$

Substitute the values given in **fig. 9** into the second formula, and check these steps:

$$Y = \sqrt{0.1^2 + 0.1^2} = \sqrt{0.01 + 0.01}$$
$$Y = \sqrt{0.02} = 0.1414S$$
$$Z = \frac{1}{Y} = \frac{1}{0.1414} = 7.07\,\omega$$

Note that in any simple R and X parallel circuit the total Z will always be less than either of the R or X component values. As you might expect, a parallel R and X_C would be solved in exactly the same way as a parallel R and X_L. In the inductive circuit the phase angle of the source current would be lagging, in the capacitive case the current would be leading, but not by 90 degrees.

If a capacitor is added across a parallel R and X_L circuit, as in **fig. 10**, we have a parallel RLC circuit. Since the B_C and B_L values would plot 180 degrees apart (as their X_C and X_L values do), the total susceptance, or B_t, will be equal to the smaller susceptance subtracted from the larger. (Do not subtract X_C from X_L in parallel circuit computations!) In our problem, the formula is expanded to subtract B_L from B_C, and is worked as shown. Can you follow each step?

$$Y = \sqrt{G^2 + (B_C - B_L)^2}$$
$$Y = \sqrt{0.04^2 + (0.05 - 0.02)^2}$$
$$Y = \sqrt{0.04^2 + 0.03^2}$$
$$Y = \sqrt{0.0016 + 0.0009}$$
$$Y = \sqrt{0.0025}$$
$$Y = 0.05\,S$$
$$Z = \frac{1}{Y} = \frac{1}{0.05} = 20\,\omega$$

If you think about it a little, you will see that if X_C and X_L happened to be equal in **fig. 10**, then B_C and B_L will be equal and would cancel each other completely, resulting in a reactance value of zero. Such a circuit is said to be parallel resonant, which we will discuss later. The total impedance would then be the

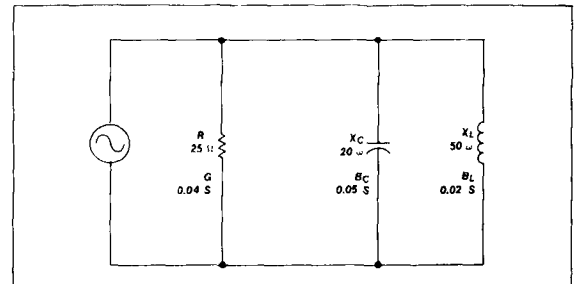


fig. 10. Parallel RLC circuit labeled with both ohms and siemens (mho) values.

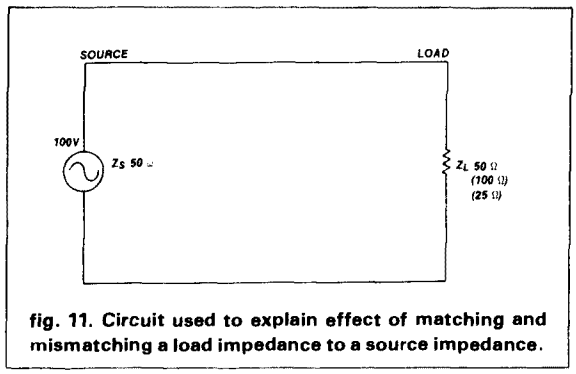


fig. 11. Circuit used to explain effect of matching and mismatching a load impedance to a source impedance.

resistance value only, or $Z = 25\ \Omega$, not 25 ω, because now the source sees a circuit that is exhibiting no reactive effects at all.

impedance matching

One of the most important requirements when operating rf ac power equipment is to match the impedance of the load to the internal impedance of the source. Consider the circuit shown in **fig. 11**. Here a load impedance (resistor Z_L) is coupled across an ac source (Z_s). Assume that the source produces 100 volts and has an internal impedance of 50 ω (or 50 Ω). Using a Z_L of 50 Ω to match the source impedance, the current through the load will be

$$I = E/Z = 100/(50 + 50) = 100/100 = 1\ amp$$

The simplest means of determining the power dissipated in the load would be by

$$P = I^2R = I^2(50) = 50\ watts$$

Incidentally, the power dissipated in the source would also be 50 watts, and the whole circuit would be 50 percent efficient.

If the load resistance is doubled, to 100 Ω, the impedances mismatch. The circuit current would now be $I = E/Z$, or 100/(50 + 100), or 100/150, or 0.66 amp. Now, the power output, or that dissipated in the load resistor, would be $P = I^2R$, or $0.66^2(100)$, or 0.436(100), or 43 watts. The power dissipated in the source would be 0.436(50), or 21.5 watts. The efficiency is 43/64.5, or 66 percent. The efficiency may be higher, but the power output into the load is lower.

If the load resistance is halved, to 25 Ω, the impedances again mismatch. The circuit current would now be $I = E/Z$, or 100/(50 + 25), or 100/75, or 1.33 amps. The power output in the load would now be $P = I^2R$, or $1.33^2(25)$, or 1.77(25), or 44.25 watts. Again the power output is less than when the impedances matched. The power dissipated in the source is now $P = I^2R$, or $1.33^2(50)$, or 1.77(50), or 88.5 watts. With this mismatch the efficiency is only 44.25/132.75, or 33 percent. So, if you have a transmitter with 50 Ω output circuit you had better be sure that the antenna you couple to it also has an impedance as close to 50 Ω as it is possible to arrange. This way you will get maximum power into your antenna.

Transformers can be used to match impedances, particularly in audio frequency ac circuits. If a transformer has a primary with 100 turns and a secondary with 300 turns, it will step up any ac voltage applied to it by three times (may be shown as either a 1:3 or 3:1 ratio). If 2 volts ac is applied to the primary, the secondary voltage should be 6 volts. If a transformer is used to match impedances, a 1:3 transformer will convert the primary impedance by a factor equal to the turns ratio squared. Thus a 1:3 turns ratio allows the transformer to convert the output or secondary impedance to 3^2, or to 9 times the impedance of the primary. Formulas that may be used are

$$\left(\frac{T_P}{T_S}\right)^2 = \frac{T_P}{T_S} = \sqrt{\frac{Z_P}{Z_S}}$$

These formulas say that the turns ratio squared equals the impedance ratio, or the turns ratio equals the square root of the impedance ratio. As an example, you want to match a 30 Ω transistor output circuit to a 4 Ω loudspeaker, fig. 12. What ratio transformer should you use? With the second formula, if the impedance ratio is 30/4, or 7.5:1, the turns ratio must be equal to the square root of 7.5 (or $\sqrt{7.5}$), or 2.74:1. Actually, either a 2:1 or a 3:1 turns ratio transformer would operate quite satisfactorily, with the 2:1 possibly sounding a little better, although somewhat weaker. The higher the load impedance the less audio distortion that may be produced.

With air-core radio-frequency transformers, impedance matching is usually controlled by the degree of primary-to-secondary coupling. The tighter the coupling the lower the impedance reflected back into the primary circuit.

series and parallel resonance

Whenever the X_C of an ac circuit matches the X_L in series with it, a condition of resonance occurs. If the capacitor and coil are in series the circuit is said to be resonant, or series resonant, **fig. 13A**. If the capacitor and coil are in parallel the circuit is said to be anti-resonant, or parallel resonant, fig. **12B**. These two resonant type circuits do not behave the same in any way.

In a series resonant circuit, as in fig. **13A**, the two reactances completely cancel the reactance effects of each other. In any series circuit there is only one current. In the series resonant circuit the X_C voltage

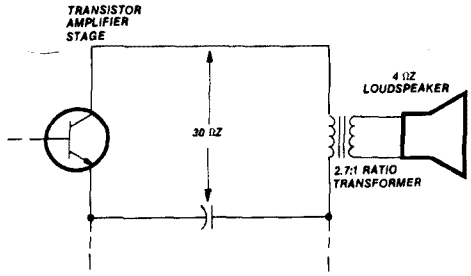


fig. 12. Transformer needed to match a 30-ohm Z to a 4-ohm load.

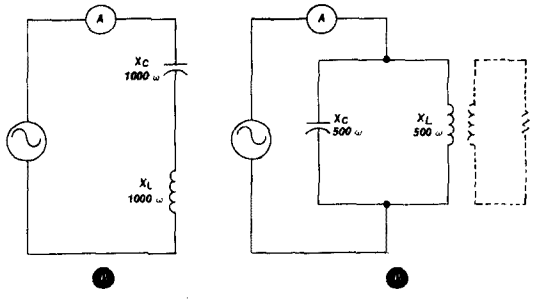


fig. 13. (A) Resonant or series resonant circuit. (B) Anti-resonant or parallel resonant circuit, with possible means of coupling to a load.

will lag the current by 90 degrees, and the X_L voltage will lead the current by 90 degrees. These two equal but opposite voltages (180 degrees out of phase) cancel, leaving the source looking at a zero voltage-drop load, or a short circuit. A series resonant circuit acts as an impedance of zero ohms, and if there is no resistance in the line the ammeter and the source might burn up.

In an anti-resonant, or parallel resonant, circuit, as in **fig. 13B**, the two reactances cancel each other in another way. Since the current lags in an inductor and the current leads in a capacitor, at anti-resonance there is one voltage across the circuit, with equal but opposite currents in the two reactances. A 90-degree current lag + a 90-degree current lead means the two currents are 180 degrees out of phase. If the current flows up in the inductor and an equal current flows down in the capacitor, there is zero current demand from the source. The source sees the circuit as no load at all, or as infinite impedance ($Z = \infty\Omega$, since the reactances cancel). The ac current circulates back and forth between the L and C, but the source is required to produce no further current once the current starts oscillating back and forth in the LC circuit at the LC circuit's resonant frequency. The ammeter would read zero amperes once the LC circuit current starts oscillating. If there were any resistance anywhere in the LC circuit there would be a $P = I^2R$ loss in the resistance, and the meter would read the current value needed to support this power loss. Also, if a secondary coil is coupled to the inductor of the LC circuit and the secondary has a resistance load on it, this load will reflect back a resistance effect into the LC circuit coil, and the ammeter will read higher. The tighter the coupling the higher the ammeter will read, and the greater the power output, until the reflected resistance value drops below the source impedance value. This would represent overcoupling, an impedance mismatch, and less power output.

There is a very significant point about oscillating LC circuits. If there is no resistance in them, once they start oscillating theoretically you can disconnect the source and the LC current will continue to oscillate indefinitely. Of course there is no such thing as a resistance-free circuit. The more resistance in the LC circuit the faster the amplitude (strength) of the oscillating current will damp (die) out. This ability to maintain an oscillation in an LC circuit is known as flywheel effect. It is the basis of operation of all oscillator circuits using LC circuits and determines their frequency of operation.

Most resonant circuits in radio have either the L or the C made variable so that the reactances can be made to be equal at some desired frequency of operation.

The basic formula of oscillation for any resonant or anti-resonant circuit is:

$$X_C = X_L \quad or \quad \frac{1}{2\pi fC} = 2\pi fL$$

From the second form of the formula we can algebraically rearrange the symbols to develop formulas to tell us, for example, what capacitance is needed to match a given inductance for a certain frequency of operation. These formulas are:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$C = \frac{1}{(2\pi f)^2 L}$$

$$L = \frac{1}{(2\pi f)^2 C}$$

where f = frequency in hertz, Hz

C = capacitance in farads, F

L = inductance in henrys, H

For example, if you have a known value coil and known value capacitor and you connect them in parallel (or series), use the first formula to determine the

frequency at which they will be anti-resonant (or resonant).

If you have a known value of inductance and you want to know what value of capacitance is required to bring such an LC circuit to resonance at a given frequency, use the second formula.

If you have a known value of capacitance and you want to know what value of inductance to use with it to make it oscillate at a desired frequency, use the third formula.

Before we start wrestling with very big and very small numbers, let's make sure you understand powers of 10. For example:

$$1 \times 10^1 = 10$$
$$1 \times 10^2 = 100$$
$$1 \times 10^3 = 1{,}000$$
$$1 \times 10^6 = 1{,}000{,}000$$
$$1 \times 10^9 = 1{,}000{,}000{,}000$$
$$1 \times 10^{12} = 1{,}000{,}000{,}000{,}000$$

In other words, the power (number) attached to the 10 indicates how many zeros to add after a 1. Thus, 3×10^6 means $3 \times 1{,}000{,}000$, or 3,000,000. Also, 4,250 can be expressed as 4.25×10^3.

We can also use powers of 10 to express small numbers:

$$1 \times 10^{-1} = 0.1 \text{ (one tenth)}$$
$$1 \times 10^{-2} = 0.01 \text{ (one hundredth)}$$
$$1 \times 10^{-3} = 0.001 \text{ (one thousandth, m)}$$
$$1 \times 10^{-6} = 0.000\,001 \text{ (one millionth, } \mu\text{)}$$
$$1 \times 10^{-9} = 0.000\,000\,001 \text{ (one billionth, n)}$$
$$1 \times 10^{-12} = 0.000\,000\,000\,001 \text{ (one trillionth, p)}$$

A negative power (such as 10^{-3}) indicates how many decimal places to put in front of a number. Thus, 3×10^{-6} means $3 \times 1 \times 10^{-6}$, or $3 \times 0.000\,001$, or 0.000 003, which is three one-millionths. Also, 7.35×10^{-4} can be expressed as 0.000 735 by moving the decimal point over four places and inserting the necessary zeros. Note that 10^0 indicates unity, or 1.

Just for fun, let's see if we can engineer a coil and capacitor LC circuit that will resonate at 4 MHz, which is one edge of the 80-meter Amateur band. Assume we have a 50-pF capacitor to start with. What inductance coil do we need? Using the third formula, and plugging in the given values,

$$L = \frac{1}{(2\pi f)^2 C}$$

$$L = \frac{1}{[2(3.14)(4 \times 10^6)]^2\,(0.000\,000\,000\,05)}$$

$$L = \frac{1}{(2.5 \times 10^{14})(5 \times 10^{-11})}$$

(Now subtract 10^{-11} from $10^{14} = 10^3$)

$$L = \frac{1}{3.155 \times 10^3} = \frac{1}{31{,}550}$$

$$L = 0.000\,0317 \text{ H or } 31.7\ \mu\text{H}$$

A difficulty with LC circuits is all of the stray resistances and capacitances that may occur in circuits. These can degrade the operation of a resonant circuit. For one thing, all wires have some resistance, and as a result the Q of LC circuits tends to be lowered. Q can be thought of as meaning quality. A coil with little resistance is essentially all inductance and no resistance. Its quality as an inductor is high. Q can be determined by

$$Q = \frac{X_L}{R} \quad \text{or} \quad Q = \frac{2\pi f L}{R}$$

From the second formula form it would be assumed that as frequency (f) increases the Q would also increase. However, when ac current flows in a wire the CEMF tends to force electrons to flow less in the center of the wire and more on the outer surface, or skin, of the wire. Constricting the usable volume of a wire makes the wire appear to be smaller to the ac current, and the wire exhibits greater resistance to the current flow. This is called skin effect. Skin effect increases the R value in the Q formula, tending to lower the Q at higher frequencies.

Since capacitors have very little wire associated with them they tend to have high Q, even though the Q of a capacitor can be computed by the formula $Q = X_C/R$ also. In an LC circuit the Q is usually assumed to be essentially that of the coil. However, when loaded (ac power coupled out of it), an LC circuit's Q lowers. A high-Q rf LC circuit in a radio receiver, for example, may have a Q value of perhaps 100 or more. If loaded normally, the working Q of a transmitter amplifier LC circuit may range from perhaps 8 to 15. If overcoupled the Q may drop below the value of 8. Adding resistance in series with either the capacitor or the inductor of an LC circuit, or across the circuit, will lower the circuit's Q.

Consider an LC circuit connected across an ac source whose output ac frequency is variable from a low frequency to a very high frequency, **fig. 14**. At a low frequency the reactance of the coil would be very low. As a result, the voltage developed across the LC circuit would be very small. Most of the ac voltage would be dropped across resistor R. At a very high frequency, the reactance of the capacitor would be very low, and again the voltage across the LC circuit would be very small. However, at some intermediate frequency, where X_L equals X_C, the two reactances cancel to form a nearly infinite impedance, resulting in maximum voltage-drop across the LC circuit and none across R. When this is graphed we see a peaked resonance curve, with the LC circuit voltage (or current) peak occurring at the frequency

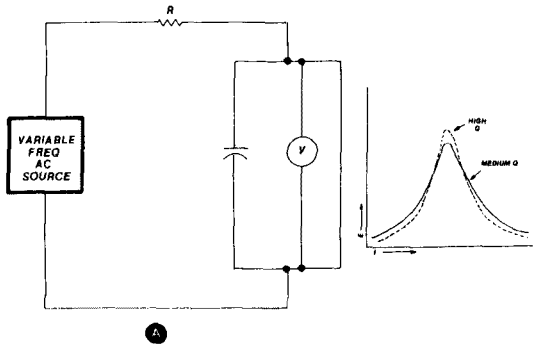


fig. 14. (A) An LC circuit across a variable frequency source of ac. (B) Frequency response curves of two LC circuits of different Qs but resonant at the same frequency.

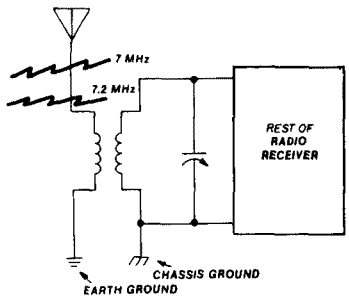


fig. 15. Resonant circuit used at the input of a radio receiver to select the desired frequency to receive.

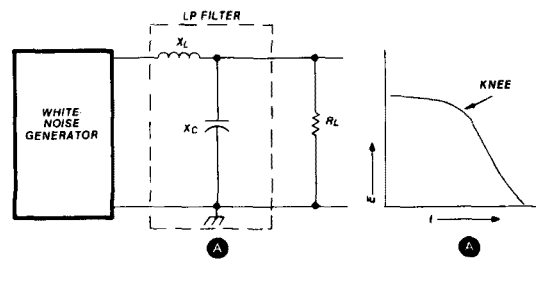


fig. 16. (A) Lowpass L-type filter and (B) response curve.

of resonance. We can read this curve to indicate that the LC circuit's response to frequencies removed from the resonant frequency drops off rather rapidly. The dashed curve indicates the relative response of a higher-Q LC circuit. The higher the Q the narrower the bandwidth of an LC circuit, and the steeper the skirts of the curve.

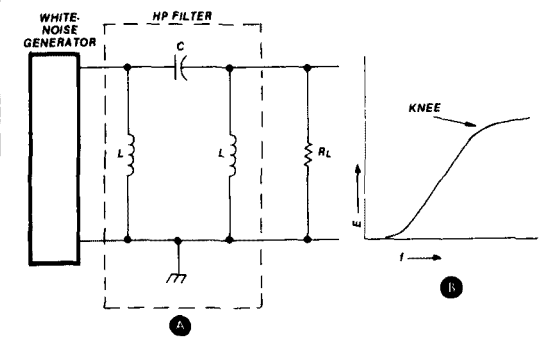


fig. 17. (A) Highpass π-type filter and (B) response curve.

An application of a resonant LC circuit is shown in fig. 15. An antenna wire is connected to a coil and the bottom of the coil is "grounded" to a water pipe or a pipe driven into the earth. Coupled to this antenna coil is the inductor of a tuned LC circuit. The LC circuit in this case has a variable capacitor to enable the resonant frequency to be changed, or "tuned." (A fixed capacitor with a variable inductor might also have been used.) There are two different frequency radio waves shown crossing the antenna and inducing two different frequencies of ac into it. If the LC circuit is made resonant to 7 MHz, the receiver will receive maximum response at this frequency, and will tend to attenuate (decrease) the response to the 7.2-MHz signal. If the capacitance is lessened so that the resonant frequency of the LC circuit is raised to 7.2 MHz, this frequency will produce maximum signal for the receiver and the 7 MHz signal will now be attenuated. The basic idea of a radio receiver is to use tuned LC circuits to select which frequency is to be received. The higher the Q of the LC circuit the narrower the bandwidth or the more selective the LC circuit and the receiver will be. Bandwidth is usually measured from the low frequency half-power point on the resonant curve, through resonance, to the half-power point on the high frequency half of the curve.

The bandwidth of an LC circuit is determined by Q, in the ratio

$$BW = \frac{f_o}{Q}$$

where BW = half-power point frequencies (in Hz, kHz, or MHz)
f_o = resonant frequency (in same units)

In general, the higher the frequency of resonance the wider the bandwidth that LC circuits will have. The LC circuits of 28-MHz Amateur band circuits will have much wider bandwidths than 3.5-MHz band cir-

cuits. It will be harder to tune out nearby frequencies on the higher frequency bands.

filter circuits

While most ac signal generators generate only a single frequency at one time, there are some special devices that can generate what is called white noise. This term denotes the production of a broad spectrum of frequencies all at the same time, from a few hertz to hundreds of megahertz. If a white-noise generator's output is fed through an L-type (from its L shape) lowpass filter, **fig. 16A**, only the low frequencies will pass through, and the high frequencies will be attenuated as indicated by the curve of **fig. 16B**. The circuit of this LP filter can be analyzed as having the X_L passing low frequencies (low reactance to them) to the load resistor, and opposing or attenuating higher frequencies. The X_C has almost no shunting (shorting) effect on low frequencies, but acts as a shunt or short circuit across the circuit for high frequencies. The larger the L and C values used the lower the frequency that the knee of the response curve will have. For audio frequency work, iron-core inductors are used.

If the positions of the L and C are reversed, as in **fig. 17A**, and a second inductance is added, a π-type (from its π shape) highpass filter results. The drop-off past the knee of the curve is much steeper (**B**) with the added component. In fact, the more components used in filters the steeper the skirts become.

Another form that filters take is the T type (from their component configuration), **fig. 18**. This is also a highpass filter, and can have characteristics similar to those of the filter in **fig. 17**.

Two resonant circuits connected as shown in **fig. 19A** produce a band stop filter. If both are tuned to the same frequency, **6** MHz for example, XL_1XC_1 acts as an infinite impedance to this frequency and almost none of this frequency can pass through the filter. If any does, then the zero impedance of the series resonant circuit, XL_2XC_2, shorts the ac signal at that frequency to ground. A band stop filter is also known as a notch filter. Frequencies on both sides of resonance will pass, **fig. 19B**. If the two LC circuits are resonant to different frequencies, perhaps 1 kHz apart, the curve will flatten off at its base (dashed curve) rejecting a wider group of adjacent frequencies, increasing the bandwidth of the filter. If only one resonant circuit is used to stop a frequency, such an LC circuit may be termed a wave trap. Wave traps are handy circuits for keeping unwanted rf ac out of electronic equipment. Band stop filters are sometimes called stop-band filters.

If the resonant circuit positions are reversed, as in **fig. 20A**, the circuit becomes a bandpass filter. Both circuits work to pass the frequency to which they are tuned. An air-core transformer with either or both primary and secondary tuned to the same frequency is also a form of bandpass filter. Several of these are used in every receiver and transmitter.

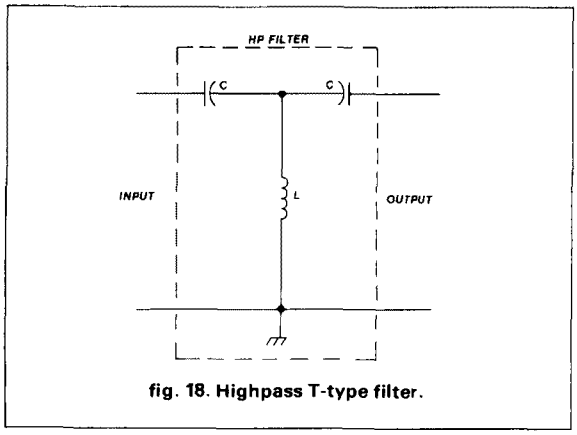


fig. 18. Highpass T-type filter.

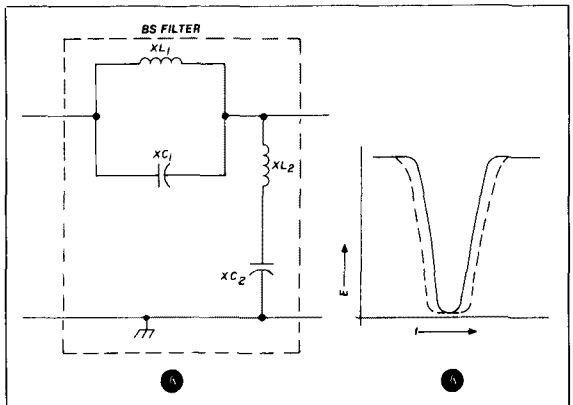


fig. 19. (A) Stop-band L-type filter and (B) response curve.

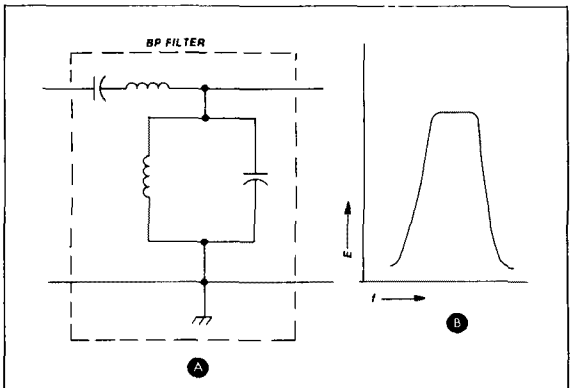


fig. 20. (A) Bandpass L-type filter and (B) response curve.

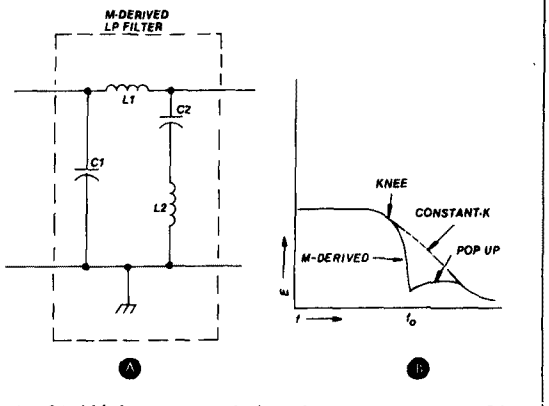


fig. 21. (A) A π-type m-derived lowpass filter and (B) a possible response curve.

The simple lowpass and highpass filters of **figs. 16** and **17** are known as constant-k filters because if the X_L and X_C values are multiplied together for any one frequency, the same product value (or k) will be produced at any other frequency. These filters do not have very steep skirts unless many similar sections are used in cascade (one following the other). Since every section produces some attenuation of the signal being passed through it, many-section filters may have excessive attenuation values.

Another form of LC filter, called an m-derived filter, uses a resonant circuit in it to force a steep slope. An example of a π-type m-derived lowpass filter is shown in **fig. 21A** with its response curve, **fig. 21B**.

Inductor L_1 and capacitor C_1 pass low frequencies but attenuate highs as in any lowpass, constant-k filter. The series resonant LC circuit shorts out its resonant frequency, f_o, but the response pops up past this frequency until it meets the descending constant-k response, shown dashed. The m value refers to the difference in frequency between the knee of the constant-k part of the filter and f_o. If the knee frequency and f_o are the same, $m = 0$ and the circuit acts like a constant-k filter with a wave trap in it. If the frequency at the bottom of the constant-k curve and f_o are the same, $m = 1$ and the circuit acts as a simple constant-k filter. An m value of about 0.6 gives a rapid drop-off and relatively little pop up past f_o, and is often the m value used.

The m-derived filters can be made in the π-type LP form as shown, or in HP, BP, and BS forms. Composite filters can be made with some constant-k sections cascaded with one or more m-derived sections. All filters are engineered to operate from and into given impedance values. If the proper impedances are not used, the filter will not work properly.

If resistors are substituted for the inductors in constant-k-type, highpass and lowpass filters, the steepness of the resulting curves are not very good. However, in many cases an RC filter will do the job adequately. They are much lighter and less costly than LC filters.

black box circuits

The FCC speaks of replacement of a voltage source and a resistive voltage divider with an equivalent circuit consisting of a voltage source and one resistor. This is an application of what is known as Thevenin's theorem, which says in effect, "Any complex resistive circuit with one or more voltage sources in it may be replaced with an equivalent operating circuit consisting of a single series resistor and a single voltage source."

The "black box" of **fig. 22** illustrates a resistive voltage-divider circuit and a battery inside the box. All we can see of this circuit are points **A** and **B**. Effectively, what *single* resistor in series with a single battery will work the same as this more complex circuit as far as any load connected across terminals **A** and **B** is concerned?

The answer to this can be determined by using a resistor load, an *ammeter in series* with it, and a voltmeter, as indicated. First, we measure the **A** to **B** voltage with no load. Let's assume it is 25 volts. Next, connect the load across **A** and **B** and read the voltage again. We will assume it is now 20 volts. We *can* say that connecting the load produces a change in voltage (delta V, or dV) of d5 volts. When no load is connected, the external current flow is zero amperes. Let's assume that with the load connected the current is 0.8 amp. This means that changing from load to no-load conditions produces a d0.8 amp. Using our delta values in the Ohm's law resistance formula results in $R = dE/dI$, or d5/d0.8, or 6.25 Ω internal resistance. Since we know that the effective internal EMF is 25 volts, the internal circuit could be replaced with a 25-volt battery and a 6.25Ω resistor in series.

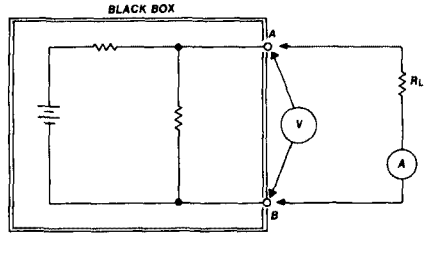


fig. 22. Black box and means of determining effective internal voltage and resistance.

FCC test topics

Although there are no specific Novice FCC test topics in this article, it would be wise for Novice applicants to begin to learn the necessary theory for future Technician/General, Advanced, and Extra class licenses.

The following Technician/General class FCC test topics are discussed in this article, but should be understood by Advanced class license applicants also:

Reactance

Impedance

Electrical power calculations

Power measurement

Series and parallel combinations of resistors, of capacitors, and of inductors

Impedance matching

Turns ratio, voltage, current, and impedance transformations in transformers

Highpass, lowpass, and bandpass filters

The following Advanced class FCC test topics are discussed in this article, but should be understood by Extra class license applicants also:

Phase angle between voltage and current, given resistance and reactance

Reactive power

Power factor, given phase angle

Series and parallel resonance

Selecting a coil or capacitor to resonate at a given frequency

Resonant frequency, bandwidth and Q of RLC circuits, given component values

Skin effect

Filters: constant-k, m-derived, stop band, notch, pi-section, T-section, L-section (general characteristics, not design equations)

Replacement of a voltage source and a resistive voltage divider with an equivalent circuit consisting of a voltage source and one resistor.

Problem answers: 1: 89.4 ω. **2:** 1.4286, 55 degrees, 0.5736, 73.2 ω. **3:** 0.833, 39.80 degrees, 0.7682, 39.05 ω, 2.561 amps, 76.83 volts, 64.03 volts, 196.8 watts; it leads.

For additional information on these subjects you can refer to *Electronic Communication*, by Robert L. Shrader, W6BNB, McGraw-Hill Book Company, available through Ham Radio's Bookstore.

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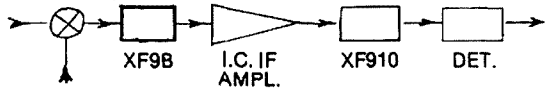


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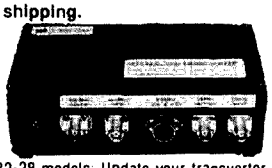
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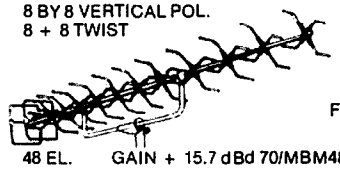


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Loading problems and cures with regard to solid-state transmitters

ham radio TECHNIQUES

Bill Orr W6SAI

My column "A Survey of Antenna Tuners" in July, 1981, *ham radio* brought some feedback in the form of interesting mail. The subject under discussion was the problem of loading a solid-state, high-frequency transceiver into some of today's modern antennas. Many proud users of the latest in ham gear experienced loading problems, feedback, TVI, erratic operation, a "hot" microphone and other melancholy exceptions to normal operation.

What is the problem? What causes this unusual plague of difficulties?

It seems to reduce down to this: The modern, state-of-the-art, high-frequency transceivers with transistor output stages all have one thing in common — they provide their full power into an antenna load *only* under conditions of a *low* SWR on the transmission line. Many solid-state transceivers, when presented with a high-SWR antenna load, simply start to turn themselves off. As an example, one popular transceiver, when working into an SWR of about 2 to 1, will reduce its output by 25 percent (100 watts to 75 watts). And when the SWR reaches about 3 to 1, the transceiver output drops by 50 percent (100 watts to 50 watts).

Someone may say "small potatoes," but a 50-percent power drop is a signal loss of 3 dB, and when the user is paying for the power, I don't see why he can't use it! **Fig. 1** sums up the problem.

what to do about loading problems

Perhaps the loss in power output is not important, but the attending problems mentioned previously are often coupled with the SWR problem. It is all of one piece, so to speak. The answer, then, is to tailor the *antenna system* to provide a better and more compatible load for the solid-state equipment.

From the mail I get on the subject, the antenna that seems to provide the greatest loading problems is the popular tri-band Yagi beam for 10, 15, and 20 meters. Sometimes this antenna is a "bearcat" to tame, especially on 10 meters. So let's take this antenna as an example, remembering that the discussion applies to other antennas as well.

The problem breaks down into two separate parts. First, getting the rf power where it belongs — into the antenna — and not where it is liable to end up — in the telephone wires, utility wires or Grandpa's new stereo system. Second, making the antenna system compatible with the transceiver so the latter "looks into" a reasonably low value of SWR. Neither problem is insurmountable.

getting the rf power where it belongs

It is easy to allow the output power from your transmitter to get into outlandish places. A favorite 40-meter dipole of mine had to be taken down because when I ran a few hundred watts into it, the dining room light fixtures illuminated by themselves, even with the light switch in the off posi-

tion. And a friend of mine had a talking garbage disposal whenever he went on 15-meter SSB. Many operators have been bitten from a "hot" microphone on 10 meters. Sometimes speech processors break into oscillation, or loading changes when the microphone is grasped.

All of this means that the transmitter rf is getting where it is not supposed to be — into the power mains and back *into* the transmitter's exciter stages. There are several ways to combat this problem.

First, it is bad medicine to have the station in the near-field of the antenna. Getting the antenna up in the air, away from the station equipment, helps a lot. When the antenna is on a short tower right above the radio room, the station equipment is exposed to the strong radiation field from the antenna. Moving the antenna away from the station is the answer. Or, moving the station away from the antenna accomplishes the same result. My antenna, for example, is on a tower near my garage. Moving the station from the garage workshop to a spare bedroom certainly helped a lot. (My wife had other ideas about that move, but that's another story.)

antenna currents

One aspect of the problem is caused by antenna currents that flow on the *outside* of the coax to the antenna. Antenna currents can be caused by current induced into the outer shield of the line because it is in the field of the antenna. The worst case is when the line length is resonant; that is, a multiple of a half wavelength at the operating frequency. Under this circumstance, you have a resonant conductor (the transmission line) in the near-field of the antenna. Maximum line pickup comes about when the transmission line runs *parallel to the antenna*.

Antenna currents can be reduced by detuning the line and moving it so that it doesn't run parallel to the antenna. In the case of a rotary beam, it is a good idea to bring the coaxial line *and* rotor control cable down to ground level and run them along the ground, or bury them inside a garden hose sunk below ground level. A bad idea is to string the coax and cable above the ground from tower to radio room. My coax and cables came off my tower at about the 10-foot (3-meter) level, then ran across the rooftop to the window of the operating room. This caused no end of problems, especially on 10 meters.

I finally dropped the wires down to ground level and brought them into the radio room through a hole drilled into the corner of a closet floor (when no one was looking). Relocating the cables improved transmitter operation and stability immensely.

The *ARRL Antenna Book* has a good dissertation on antenna currents and how to decouple the line to avoid line resonance. The solution proposed is to cut the line to a length that avoids resonance. Recommended lengths for the high-frequency bands that avoid the problem are: 27, 39, 57, 76, 95, 110, and 145 feet (8.2, 11.9, 17.4, 23.2, 29, 33.6, and 44.2 meters).

the line choke

Another approach is to wrap a few turns of the transmission line into a coil, forming an rf choke, that will suppress antenna currents that might flow on the outside of the outer shield of the coax. I have used five turns of RG-8A/U, about a foot (30.5 cm) in diameter. In one instance, where I didn't use a balun, but fed a balanced beam with a coaxial line, I noticed that my front-to-back ratio was very poor. The beam seemed to have a bidirectional pattern. The five-turn choke coil was placed in the coaxial line, atop the tower, and about 3 feet (0.9 meter) from the feedpoint of the beam. (Placement was determined by the fact that I am a coward atop the tower, hanging on with both arms and a safety belt.) Once the line was wrapped and taped into a roughly shaped coil, the front-to-back ratio of the beam improved dramatically.

Another stunt is to wrap two turns of the transmission line around a large ferrite core. I've used the Amidon T-200 (6-mix, yellow, with a $u = 8$) with two turns of RG-8A/U through it in a 12-inch (30.5-cm) diameter coil with good results, too.

summing up

So there you have it. *Don't* run your coax line parallel to the antenna elements or, if you must, run it along the ground. *Do* make sure your coax line is not resonant at your operating frequencies. Either detune the line by trimming it to the previously sug-

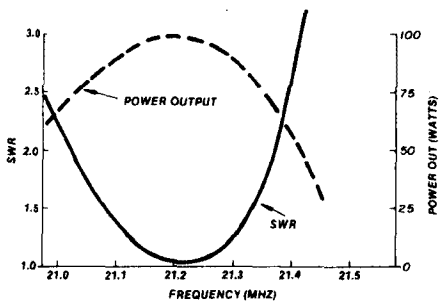


fig. 1. Representative SWR *vs* power output for solid-state transmitter. As SWR of antenna increases, power output of transmitter drops rapidly. At 21.45 MHz, for example, 100 watt nominal output is reduced to less than 30 watts because of high SWR on antenna system. A line flattener will reduce input SWR and boost power output of the transmitter.

gested lengths, or wrap a portion of the line into an rf choke. Bring the line *down* the tower — *don't* run it off at an angle below the antenna.

if all else fails

Sometimes attention to antenna currents on the transmission line doesn't completely solve the problem of rf feedback, a "hot" microphone, or RFI (Radio Frequency Interference). I know. Some years ago I lived in an area remarkably free of TVI. I had no TVI problems, including TVI in my own home. One fine day a neighbor decided to add an extra room to his garage — sort of a combined rumpus room and workshop. No sooner was the room added when the neighbor complained to me of severe TVI from his new set installed in the garage room. Sure enough, I wiped it out! And a highpass filter in the TV lead in didn't seem to do any good.

Well, after a lot of fruitless investigation, on-the-air checks, and so on, we discovered that the TVI on this particular receiver could be completely eliminated by merely moving the set from the garage room back into the house!

It seems that my neighbor's house, my house, and the surrounding houses had been wired with solid electrical conduit. That is, all electric wiring was encased in metal conduit which, in turn, was grounded at several points in the homes.

To save building costs, my neighbor decided that conduit was too expensive, so his new garage room was wired with exposed, knob-and-tube wiring! The result was that the electrical wiring acted as a giant antenna, picking up my signal and pumping it directly into the power line of the TV set. Moving the set back into the house, which was wired with solid shielded conduit, completely protected the vulnerable input circuits of the receiver.

What to do? Investigating around the attic area of the new room revealed that the 120-volt wiring was as "hot as a baker's apron" when I was on 20 meters, less so on 15 meters, and again sensitive to 10-meter operation.

It was impossible to retroactively shield the wiring, so an attempt was made to cool things off. At every wall outlet each side of the power line was bypassed to the neutral wire (a three-wire circuit: 120 volts, 120 volts, and ground) with 0.01-μF 1.4-kV disc ceramic capacitors, rated for 125 volts ac and 1400 volts dc. (The capacitors are tested at 2800 volts.)

Three well known manufacturers that supply these line capacitors, and their type number are: Aerovox type AC-7, Centralab type CI-103, and Sprague type 125L-S10. These capacitors, or their equivalents, are suitable for the 120-volt, 60-Hz power line. *Do not* use garden-variety 600-volt disc ceramic capacitors, as they are not rated for this service.

Bypassing the line at various points helped to clean up the trouble, and when a highpass filter was placed in the ribbon line to the TV set, it did the job. Result: no more TVI in the new garage room!

the line flattener

Taming the rf floating around the radio room and cleaning up your neighbor's receiver doesn't go all the way in solving the loading problems inherent in some solid-state rigs, but it surely helps. The last trick in the deck is to use a *line flattener* — this is a simplified matching network that is placed between the transmitter and the antenna to reduce the SWR on the line to a value acceptable to the transmitter. Mind you, the SWR at the antenna and on the line doesn't change — the line flattener is merely a matching device that makes the real world more palatable to the station equipment. A good line flattener can drop an SWR of more than 5 to 1 to unity in the wink of an eye!

The schematic of a line flattener for power levels up to 250 watts PEP (or slightly more) is shown in **fig. 2**. A connoisseur will recognize this circuit as a simple pi network with three adjustable components. The line flattener is inserted into the transmission line *after* the SWR meter, and the

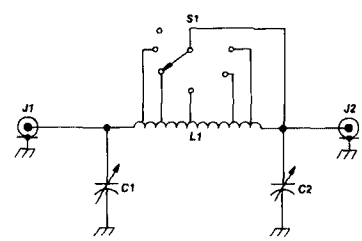


fig. 2. Line flattener for coaxial cable. Many components for the line flattener can be found in the junk box. J1, J2 are coaxial receptacles to match the plugs used in your antenna system (type SO-239 receptacles mate with plug PL-259, for example). Capacitors C1 and C2 are 100 pF (for 10-15-20 meter operation) and 250 pF for 40-80 meter operation. Single-spaced, receiving types will be satisfactory for power levels up to 100 watts PEP output. For higher power levels, the surplus capacitors found in the BC-series "Command" transmitters are ideal. Fair Radio Sales, in Lima, Ohio, has a good selection of transmitting capacitors.

The coil, L1, is ten turns of No. 12 (2.1 mm) 1 inch (2.54 cm) diameter and 1-1/2 inches (3.8 cm) long (10-15-20 meters); 20 turns, 1 inch (2.54 cm) diameter 3 inches (7.6 cm) long (40-80 meters). Five taps, every other turn on every fourth turn. The coil is not critical; the air-wound type is satisfactory, or it may be hand wound on a ceramic form. Use what you have. Switch S1 is a ceramic affair with an insulated shaft extension. Or, it may be mounted on an insulated plate affixed over an oversized panel hole. Remember: the arm of the switch is at rf potential. Again, Fair Radio Sales is a good choice for suitable switches.

controls are adjusted to reduce the SWR to a minimum value. Suitable components for the line flattener are listed in the drawing caption.

To keep everything shipshape and rf tight, the line flattener should be built into an enclosure such as an aluminum utility cabinet. The Bud AU-1040, measuring 9 by 6 by 5 inches (22.8 by 15.2 by 12.7 cm), will do the job as will any equivalent cabinet that is all-metal and does not have plastic end panels. The input and output coaxial fittings can go on either end of the cabinet, or on the rear, depending upon your particular equipment layout.

It is a good idea to use extra screws to hold the box panels in place; the box is pretty leaky when it comes to rf shielding. And don't forget to clean any paint off the mating lips of the box and panels to make a good electrical joint.

tuning the line flattener

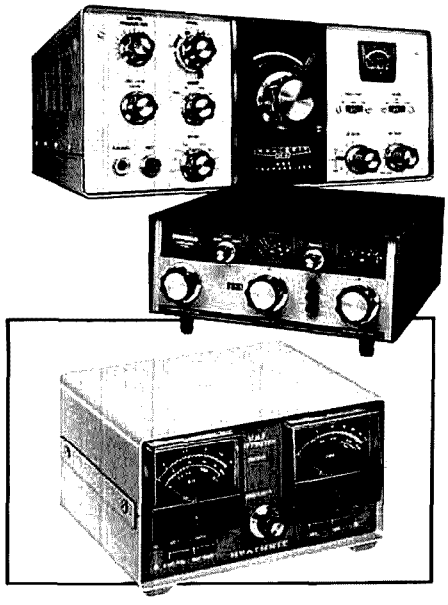
Easy! Place the SWR meter between the line flattener and the coax line to the transmitter. You'll need a short, extra length of line to reach from flattener to transmitter. And *be sure* to properly install *all* coax plugs on your antenna line as recommended by the manufacturer. A sure-fire way to get into trouble is to improperly use the connectors. The temptation is great to jam the connectors onto the cable and forget about soldering the shield and inner conductor. *Don't do it!*

When everything is together, fire up the transmitter and adjust the controls of the line flattener for the lowest value of *reverse power* (or SWR) as read on the SWR meter. That's all there is to it. Log the control settings for each band for future use.

Need more information on antennas, feedlines, and beams? Read *The Radio Amateur Antenna Handbook,* by W6SAI and W2LX. It's available from Ham Radio's Bookstore, Greenville, NH 03048. Price, $6.95 plus $1 to cover shipping and handling.

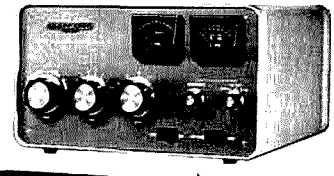
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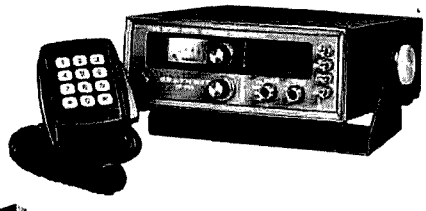
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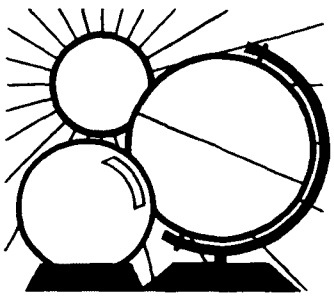
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DX FORECASTER

Garth Stonehocker, KØRYW

last-minute predictions

The lower-frequency bands are expected to be favored for DX for the first half of the month; then the higher bands, 10-15-20, will pick up with excellent openings in the last part of the month. Some periods of disturbance may be experienced around the 10th, 19th, and 30th, with fairly lengthy (3-5 days) of low signal strengths on polar paths and excellent trans-equatorial long-hop openings. Both paths may have some QSB and DX from unusual locations associated with the disturbances.

October is an equinoctial month so expect more than normally disturbed conditions. The solar flux is still high enough in the declining part of the 11-year cycle to give good high maximum usable frequencies for trans-equatorial propagation. The 10 and 15 meter bands have most of this type propagation as one can see on the paths to the south, southeast, and southwest on the chart. Even some of the 10-meter openings are marked with an asterisk, which indicates possible openings on 6 meters during that hour during the month. The best chance for these openings are during high solar flux values and high geomagnetic A or K values as broadcast from radio station WWV at 18 minutes after each hour.

During October the Orionid meteor showers are visible from the 15th to the 25th. The maximum rate is between 10-20 per hour on the 20-21st of the month. The moon is full on the 13th and perigee on the 15th of the month, which may be of interest to the moonbounce DXers.

October may be a good month to get antennas ready for the winter DX season, since the summer yard work is over. You may want to consider how effective your antennas are in coupling to the ionosphere (see January 1981 *DX Forecaster*). For getting maximum distance per hop to your favorite DX land for short skip, E region propagation of 1200 miles (2000 km) you need a takeoff angle of about 20 degrees, and for long or regular skip to about 2500 miles (4000 km) about 10 degrees. For the higher-frequency DX bands with the usual horizontal antennas this is approximately 0.75 wavelength and 1.25 wavelength heights above ground respectively. This table gives the approximate heights in feet to shoot for:

band	short skip	regular
10	25	40
15	38	60
20	50	80

Hope you have a good DX season coming up.

band-by-band forecast

Six meters should provide frequent band openings with a peak during the early afternoon hours on many days. Trans-equatorial north-south paths will be the best. Your guide to possible openings will be strong openings on 10 meters and high values of solar flux.

Ten and fifteen meters will be loaded with good DX signals from morning until early evening hours almost every day. Times of geomagnetic disturbance will limit the number of signals heard, but listen carefully — they can be from very unusual places. Fifteen meters should be open later in the day than 10 meters. So, hit 10 first and finish off with 15.

Twenty meters will be the main daytime DX band, as it is almost always open to some part of the world. It opens to the east as the sun rises and extends into the late evening hours to the west. Geomagnetic disturbances do not affect *this* band as much as the higher ones, but still look for unusual trans-equatorial DX locations to be coming through once in a while. One-hop trans-equatorial DX of 5,000 to 7,000 miles (8,000 to 11,200 km) may be possible in the late evening hours during some of these unusual conditions.

Forty and eighty meters will have much short skip during daylight hours and turn to DX after dark. The bands will open to the east soon after sundown, swing more to the south to Latin America about midnight, and end up to the Pacific areas during the hour or so before dawn. Some nights these bands will be as good as during the winter DX season *coming* up in November-February. The coastal regions usually have the edge for working the rare DX on these bands.

One-sixty meters will be quieting down substantially now. This band should have renewed interest in DX possibilities with LORAN phasing out and privileges restored. It works much like 80 meters so give it a try.

ham radio

OCTOBER

GMT	PDT	WESTERN USA												MDT	MID USA											CDT	EASTERN USA											EDT
		ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN						ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN				ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN			
		N	NE	E	SE	S	SW	W	NW						N	NE	E	SE	S	SW	W	NW				N	NE	E	SE	S	SW	W	NW			
0000	5:00	10	20	15	10	10	10*	10*	10					6:00	—	20	15	10	10	10	10	10			7:00	—	20	15	10	15*	10	10	10	10		8:00
0100	6:00	10	20	15	10	15	10*	10	10					7:00	—	20	15	10	10	10*	10	10			8:00	—	20	15	10	15	10	10	10	10		9:00
0600	7:00	10	20	15	10	15	10	10	10					8:00	—	20	15	15	15	10	10	10			9:00	—	20	15	15	15	10	15	15	15		10:00
0800	8:00	10	20	15	15	15	10	10	10					9:00	—	20	20	15	15	10	10	10			10:00	—	20	15	15	15	15	15	15	20		11:00
0900	9:00	—	—	20	15	15	10	10	15					10:00	20	40	20	15	15	10	10	15			11:00	20	20	20	15	15	15	15	20			12:00
0900	10:00	—	—	20	15	15	10	10	15					11:00	20	40	20	15	15	10	10	15			12:00	—	40	20	15	15	15	15	20			1:00
0900	11:00	—	—	20	15	15	10	15	20					12:00	—	40	20	15	15	15	20	20			1:00	—	—	20	15	15	15	20	20			2:00
0700	12:00	—	—	20	15	20	15	15	20					1:00	—	—	20	15	20	15	20	20			2:00	—	—	20	15	20	15	20	20			3:00
0800	1:00	20	—	20	20	20	15	20	40					2:00	—	—	20	20	20	20	20	20			3:00	—	—	20	20	20	20	20	20			4:00
0900	2:00	40	—	—	40	20	20	20	40					3:00	—	—	40	40	20	20	20	20			4:00	—	—	40	40	20	20	20	20			5:00
1800	3:00	40	—	—	40	20	20	20	40					4:00	—	—	40	40	20	20	20	20			5:00	—	—	40	40	20	20	20	20			6:00
1100	4:00	40	—	—	40	20	40*	20	40					5:00	—	—	—	40	20	20	20	20			6:00	—	—	—	40	20	20	20	20			7:00
1200	5:00	20	—	—	20	40	40*	20	40					6:00	—	—	—	15	20	20	20	20			7:00	—	—	—	20	20	20	20	20			8:00
1200	6:00	20	—	—	20	40	40	20	40					7:00	20	20	—	10	20	20	20	20			8:00	20	20	—	10	20	20	20	20			9:00
1800	7:00	20	20	15*	10	—	40	20	40					8:00	20	15	10	10	—	—	20	20			9:00	20	10	10*	10	—	—	20	20			10:00
1800	8:00	20	10	10	10	—	20	20	—					9:00	20	15	10	10	—	—	20	20			10:00	15	10*	10*	10	—	—	20	20			11:00
1800	9:00	15	15	10	10*	—	15	15	—					10:00	15	15*	10	10*	—	15	20	20			11:00	15	15*	10	10*	—	15	20	20			12:00
1700	10:00	15	15	10	10*	—	10	15	—					11:00	15	15*	10	10*	—	10	20	—			12:00	15	15*	10	10*	—	10	20	—			1:00
1800	11:00	15	15	10	10	15	10	15	—					12:00	15	15*	10*	10	10	10*	15	—			1:00	15	15*	10*	10	10	10*	15	—			2:00
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2100	2:00	15*	15	10	10	15	10	10	15					3:00	—	15	10	10	15	10	10	10			4:00	—	15	10	10	10	10	15	15			5:00
2200	3:00	10	20	10	10	15	10*	10	10					4:00	—	20	10	10	10	10*	10	10			5:00	—	15	10	10	10	10	10	15			6:00
2200	4:00	10	20	10	10	15	10	10	10					5:00	—	20	10	10	10	10	10	10			6:00	—	20	10	10	10	10	10	10			7:00

*Look at next **higher** band for possible openings.

DIGITAL TECHNIQUES

avoiding built-in digital-circuit problems, part two

Part one of this series stressed the importance of timing to avoid the race condition by providing examples of different counter circuits. Race conditions and spikes are found in all marginal logic designs. But all have solutions. This part of the article looks deeper into counter chains; shows methods of supply bypassing and handling switch controls; and provides methods of reducing RFI for all logic circuits.

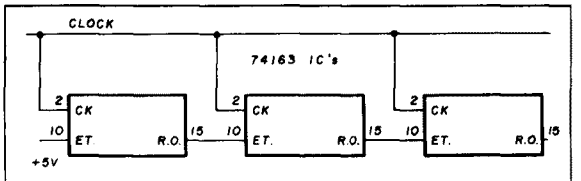


fig. 12. Suggested counter cascading for larger division ratios.

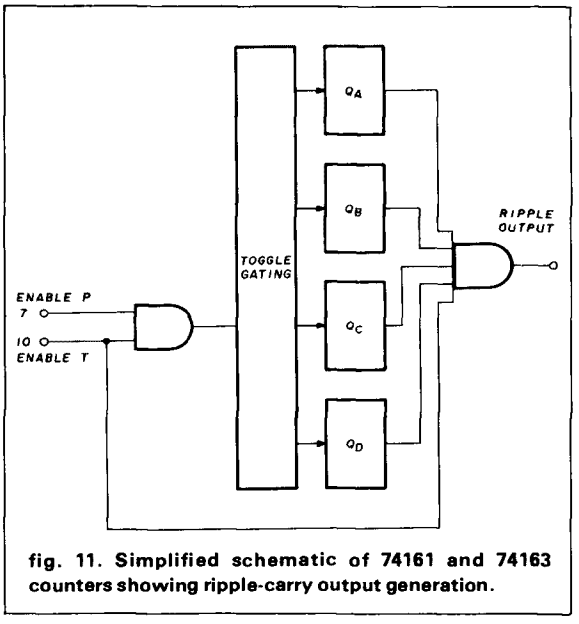


fig. 11. Simplified schematic of 74161 and 74163 counters showing ripple-carry output generation.

an inside look at a synchronous counter

Fig. 11 is a simplified schematic of the ripple carry output circuit in 74161 and 74163 counters. A carry output will not occur until all counter stages are high and the enable-T pin is high. This configuration allows cascading devices to be used, so that a carry output from the last device occurs only when all previous counters are high or logic 1.

A counter cascade, such as in fig. **12**, should work well. But I've found a situation with 74163 devices that causes a small glitch that can make the output unsuitable for driving other circuits. The cause is a small, differential delay, between a) the enable-T

By Penn Clower, W1BG, 459 Lowell Street, Andover, Massachusetts 01810.

path to carry out, and b) the counter toggling to carry out.

causes, cures and don't-cares

Spike generation is set up when all counters except the last are all ones; the last is one count less than all ones. Enable-T input of the last counter is high. Arrival of a clock edge begins to toggle all counters. All but the last go low after a short delay, while the last counter goes high.

Enable-T input of the last counter can remain high slightly longer due to its output gate delay. If this high state remains, the last counter carry output can go high for 10 to 30 nanoseconds. This short high state is shown in the lower, expanded-time trace of fig. 13. With an amplitude of about a volt, it may or

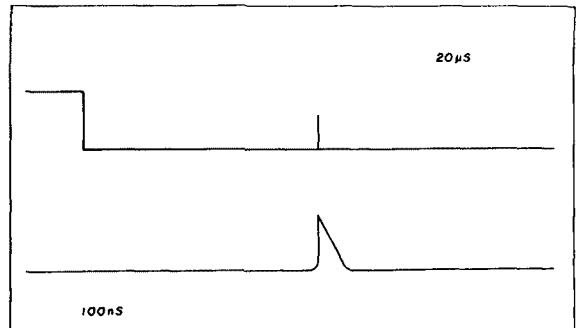


fig. 13. Dual time trace of output of last stage in counter cascade of fig. 12. Upper trace is 20 μsec per division. Bottom trace is expanded time of upper trace center at 100 μsec per division to show spike.

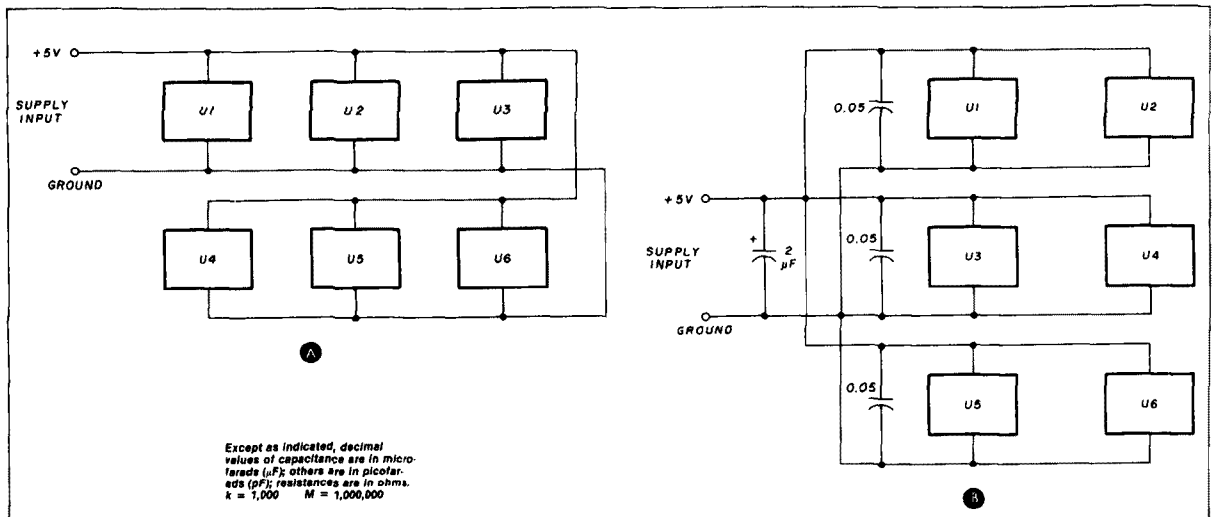


fig. 14. Supply connections with daisy chain in *A*; improved tree method in *B*. The 0.05 μF bypass capacitors in *B* smooth variations in each branch, while the 2-μF cap filters low-frequency components.

may not affect any following circuitry.

Low-pass filtering of long (breadboard) leads may mask this spike, but it can show up in the final, clean-layout circuit. One way to eliminate the spike is to carry it through a low-power inverter to the next circuit. This works with a 74L TTL inverter following a medium-speed or 74LS counter; interfamily loading rules must be followed to apply the 74L inverter properly.

If following circuits are clocked by the same counter input line, the glitch will not affect operation. Clock-triggered devices must have inputs set up *before* the clock edge arrives. The best design is one that pays attention to time delays before using any family mixes or R-C brute-force filtering. You must study all the fine print in data books.

initialization

Initialization is the process of defining starting conditions so that a sequence can begin correctly. There's no guarantee that a flip-flop will start up in a desired state, so all counter or shift register feedback gating must ensure that *any* start-up state will eventually get into the desired sequence.

A divide-by-20 counter could be made with a 20-state, circularly connected shift register. If 19 states are low and one is high, the single high bit will cycle around once for every 20 clock pulses. There must be some setup to achieve this pattern when starting; odds of starting by chance are one in 52,428.* This is

*20 acceptable patterns out of 2^{20} possibilities.

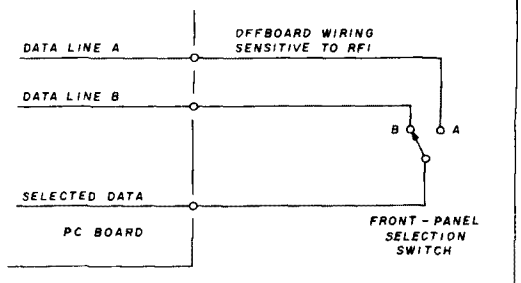


fig. 15. Example of external digital data switching. Data lines act as antennas for RFI and cannot be filtered without destroying data.

simply ones or zeroes, disregarding actual voltages. If a digital device has supply-line spikes, outputs of that device will have spikes, and a following IC may interpret these as signals.

power-supply wiring

Proper routing of power-supply currents is crucial in dense circuits. Those with a modest amount of ICs will benefit from care in routing. Supply-line spikes are generated by logic state changes in concert with parasitic supply line and ground inductance.

A clue to the ground-noise problem is a system malfunction when individual system circuits, such as breadboards, work well by themselves. Relief may be

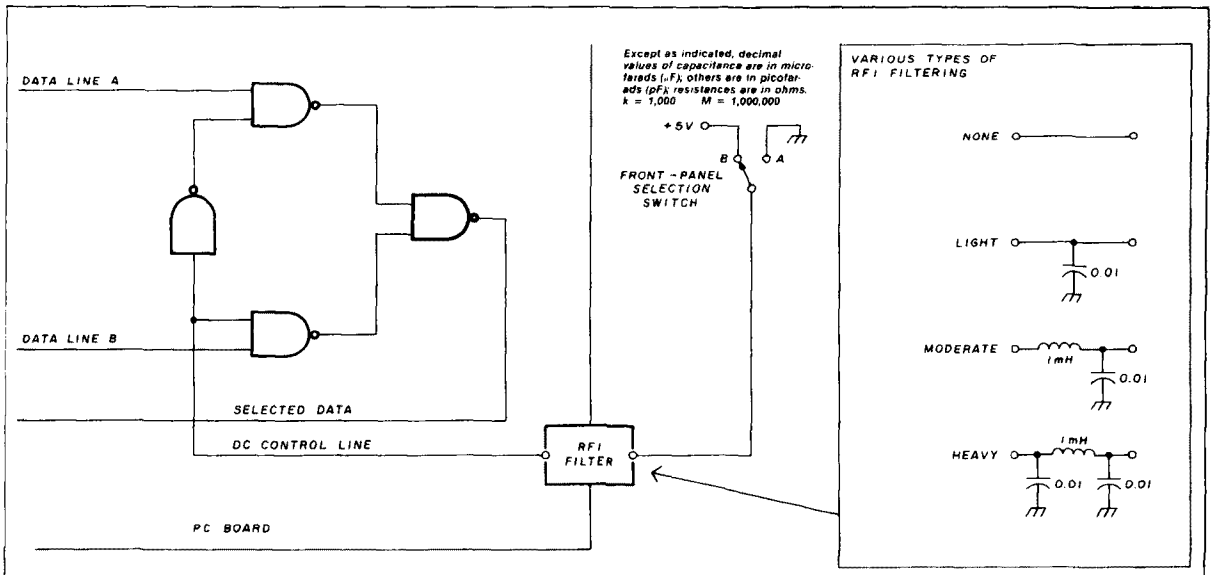


fig. 16. Improved data control allowing dc control and RFI filtering of control line. Inset shows typical RFI filter types.

an extreme chosen to make the point, but many real-life situations do occur.

Start-up states could be initialized by extra circuitry and a front-panel switch. A better way is to study the design in detail and, if necessary, add or rearrange gating for automatic initialization on start up.

layout

Anyone who has built high-gain amplifiers knows that outputs are not placed close to inputs. A completed layout is never exactly like its circuit diagram, since all components have parasitic capacitance, resistance, or inductance. Proper layout can minimize feedback and parasitics. This is also true for digital circuitry.

It is all too easy to think of digital signals as being

achieved by adding bypass capacitors directly at high-current ICs. These capacitors provide local current storage, which reduces the high-frequency current drawn through the entire supply system.

A better correction to decreasing supply impedance is a "supply tree" shown in **fig. 14**. A conventional daisy-chain supply of **fig. 14A** would make U1 susceptible to supply glitches from all others. The tree configuration of **fig. 14B** spreads supply spikes to small branches, while capacitors smooth out branch currents.

layout for the supply lines

Power and ground conductors should be as large as possible; inductance decreases as surface area increases. A good way to reduce impedance is to use

a double-sided circuit board with ground on one side, supply on the other. Supply impedance becomes quite low.*

Nonprinted layouts should avoid the supply daisy chain of **fig. 14A**. Bypass capacitors should be added locally. Ceramic caps with values from 0.001 to 0.1 μF, are typical. Leads should be short to avoid series resonance. Harmonic content of spikes is quite high, and a bypass capacitor above series resonance will become an inductor. Electrolytic or tantalum caps in the 1-10 μF range should be added to provide low-frequency smoothing on each board.

off-board wiring

Long digital lines to and from the board are susceptible to crosstalk, signal distortion, and RFI. An example is that of **fig. 15**. The panel switch is a data selector. Long lines to the switch cannot be filtered without destroying the data, and they act as antennas for rf pickup. A better solution is to add a dc-controlled digital selector on the board, such as the quad gate in **fig. 16**. External control is a dc line that can be easily filtered without disturbing data selection.

Many medium- and large-scale ICs have dc control inputs. Using these inputs allows, among other things, oscillator switching, presetting counters, and resetting flip-flops. Multiple data-line switching can be done with multiplexers such as the 74150 or 74151. Adding another device may be a bother, but the RFI elimination may be worth the expense.

curing switch-contact bounce

A clocking waveform should never be generated directly from a mechanical switch. Switches bounce, stutter, and generate a number of *transitions for* each operation.

A new pushbutton switch was connected, as in **fig. 17A**. The output appears in **fig. 18**. It can get longer and more ragged with age. The cure is to add two gates in a flip-flop latch arrangement, as shown in **fig. 17B**. The first low input from either contact will flip the latch, providing both a sharp logic step and masking the following contact bounce. Gate inputs can be heavily filtered for RFI.

explanations, experience, and understanding

Many possible explanations are available as to why a digital design doesn't work properly. Some faults may be due to inexperience, such as wrong application or lack of complete knowledge of an IC's operation.

*Commercial prototype PCBs with individual circuit bypasses are available. While expensive, they are worthy of consideration.

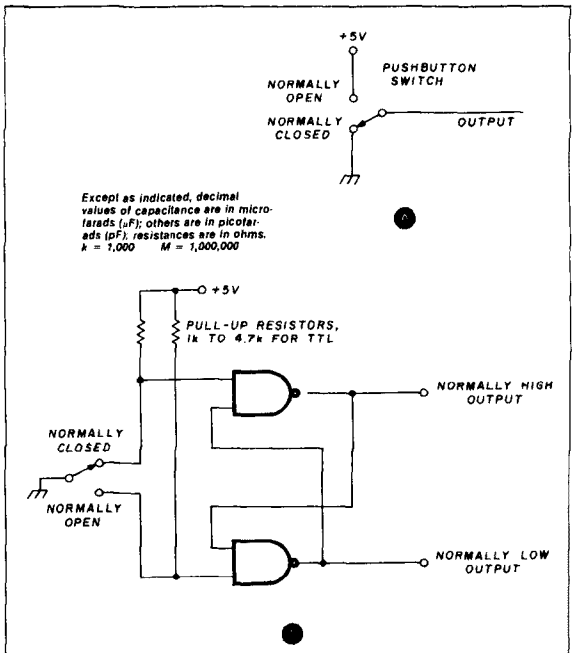


fig. 17. Simple mechanical switch circuit in *A*; improved version in *B*. Added latch gates in *B* remove bounce effects and allow RFI filtering.

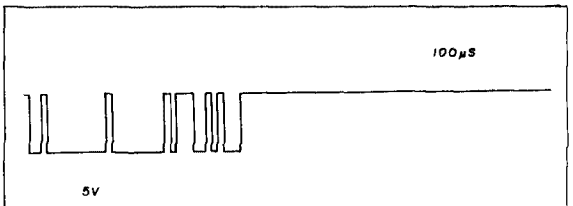


fig. 18. Output from simple switch in fig. 17-A using a new switch. Contact bounce has created at least eight positive-going edges instead of one.

As you gain more experience and learn from past mistakes, your success rate will increase. Bigger and better things will be attempted; bigger projects may have subtle problems that aren't solved by a quick flip through a data book. The purpose of this series of articles is to explain causes and cures of some of these very subtle problems.

I hope that understanding a problem will put you in a position to decide on the cure. The key to success lies in understanding *why* something hasn't worked in the past, so that you can apply the appropriate measures to the present. The alternative answer is to restrict yourself unnecessarily with a constantly growing number of design guidelines.

I shall be glad to answer letters accompanied by self-addressed, stamped envelopes, but I will not critique circuits through the mail.

ham radio

ICOM 701 owners' report

A survey of owners' opinions on the ICOM 701

In recent months, *ham radio* has presented the results of its Collins owners' survey. Thanks to all who participated. This month, we are presenting the results of our survey of the owners of the ICOM IC-701 transceiver. Ninety responses were received and tabulated.

The IC-701 is a solid-state transceiver that delivers 100 watts PEP output on all modes and bands, 160 through 10 meters. It uses a single control knob to tune built-in dual VFOs; frequency readout is by means of eight-digit LEDs. Tuning of the synthesizer can be done at either 100 Hz per division (5 kHz per turn) or 10 kHz per division (500 kHz per turn).

the good features

In response to the question, What is the rig's best feature?, the most frequent responses were small size (portability) and the built-in dual VFOs. A full 32 percent of all who responded to this questionnaire mentioned the small size of this transceiver, and its applicability as a mobile rig, as one of the best features. Thirty percent of the 701 owners who replied to the questionnaire mentioned the dual VFOs and split-frequency operation.

Other features of the 701 frequently mentioned were the solid-state advantages of the transceiver and the fact that no tune-up is necessary, the ease of operation, and the rig's stability. Here are some representative comments:

"Receiver section. Separate rf stage per band. Excellent dynamic range on 80 and excellent sensitivity on 10." — AKØP

"Stability, no-tune output." — N7BZ

"Synthesized, large digital display, dual VFOs." — KØMK

"Built-in dual VFOs, CW filters, portability (the rig was used on a mini-DXpedition to Rhodes and Crete), 100-Hz tuning segments (after I got used to it!), useful meter." — W6GBG

"Digital step tuning that allows selection of tuning speed, microprocessor interface capability, simple controls yet sophisticated capabilities, solid state finals, dual VFO system! The headphone jack that works with either mono or stereo phones is a stroke of genius!" — N1BEJ

"Reliability, no problems at all; sensitive receiver." — KB5CA

"Compactness, easy to use and operate and extremely stable. It's pretty too." — K5ESG

"Ease of operation, fast frequency change via high-speed tuning mode, and exceptionally wide bandspread in slow tuning mode. This rig is simplicity itself to operate. Once the af/rf gains and mic/CW levels are set, just tune around and operate." — WB1CHY

"Accuracy of frequency readout and ease of dropping to low power." — W5QAR

"Very easy to use, dual VFOs, good filters, etc., but mostly I like it because I just turn it on and go!" — AA7O

"Compactness, multiple features, stability, good audio on both transmit and receive, ability to interface with RTTY easily. It is a classic, ahead of its time. I own two, one mobile and one in the house." — W4VOL

"Wonderful synthesized frequency control and readout system." — W7EMP

By Martin Hanft, WB1CHQ, Production Editor, *ham radio* magazine

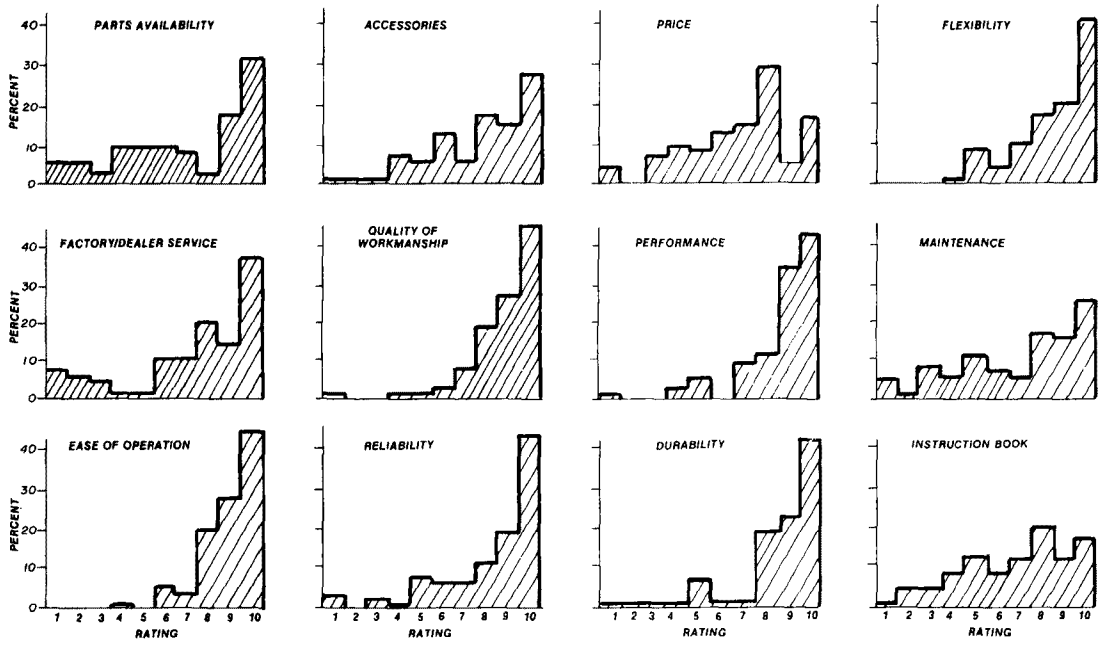


fig. 1. How the ICOM 701 was rated in each of 12 categories.

"Rotary dial with digital readout is the smoothest dial I have ever used, because of the electronic method of operation. Stability of the frequency reading is perfect and frequency itself is extremely stable. Audio quality and sensitivity are excellent!" — VE3UD

"Ease of operation. Everything you need is right up front." — KAØEJX/5

"No tuneup, just turn it on and go. Built in dual VFOs. At the time I purchased the rig there were no options available — it had everything!" — N5ADJ

"Dual VFOs built in. Ease of operation. Portability and mobile use. A lot for the money." — WA2DXJ

"Broadband tuning and high quality construction." — W2JCM

"Operating convenience." — KA1CMR

"I can swish across the band with a twist of the wrist and not have to retune the final. A great feature." — K7GCO

"Slow tuning rate makes it very easy to scan the band." — AA4RE

"Very selective and sensitive receiver, compact size, excellent speech processor. Almost no distortion with the extra average power." — NH6B

"Probably the most advanced circuitry in all hamdom." — VE3AHR

"In my opinion the fast bandswitching and QSY with no tuneup of the final is the best feature. I also am very impressed with the performance of the receiver. The frequency control features and stability are outstanding." — WA5JXC

and the bad

In response to the question, What is the rig's worst feature?, the highest percentage of respondents, 13 percent, replied that the worst feature of the 701 is the fact that the radio returns to the bottom of the band every time it is turned off. One Amateur, who apparently has power-failure problems, said that this is an inconvenience for him, especially when operating split frequency.

The second most frequent complaint was about the front-panel knobs, which were described by many as "tiny." Twelve percent of those responding mentioned the size of the knobs on the front panel. Other features named as worst included lack of passband tuning on CW, low power output, lack of full break-in, and a tendency for the finals to get too warm. Here are some sample replies to the question, What is the rig's worst feature?

"Next to impossible to repair yourself because of small size and board layout. Instruction book doesn't help much." — WB3FYL

"Seems to lack punch in a DX pileup. Power reduction occurs rapidly away from a 50-ohm load. Linears used must have tuned input."

"Non-linear VFO frequency response." — N2AQS

"When you power the rig up or change bands it

table 1. **Best feature. The percentage refers to the number of respondents who listed that feature as best. Note that many respondents listed more than one "best feature."**

	percent
small size, portability	32
built-in, dual VFOs	30
ease of operation	28
no tune-up needed	27
stability	16
broadband tuning	15
ease of changing bands	14
memory capability	10
fast/slow tune	9
receiver	9
display LEDs	8
quality construction	7
audio	7
sensitivity	7
built-in CW filters	5
narrow tuning	5
appearance	3
split frequency capability	3

table 2. **Worst feature. The percentage refers to the number of respondents who listed that feature as worst.**

	percent
automatic revert to bottom of band when rig is turned off	13
tiny knobs	12
no passband tuning on CW	9
power output too low	7
receiver overloads	7
not selective enough	6
lack of full break-in	6
inexact tuning	5
finals get too hot	5
requires low SWR	5
lack of general coverage ability	4
poor service manual	3
hard to repair	2
no expansion to WARC bands	2
hard to hook up linear	1

always starts at the bottom of the band." — WAØVNH

"Low power output." — K9GA

"Passband tuning not usable in CW mode." — AKØP

"Overloads. Shotgunning when strong signals close. Not selective enough." — N7BZ

"None." — K5STR

"Too easy to use. I am always on the air, and my XYL threatens divorce." — N9AGB

problems

The most common response to the question, Have you had any problems?, was "None." That is certainly a strong recommendation for the ruggedness of this rig. Some 36.6 percent of those responding to the survey had never had any sort of problem with the 701. The most common problem that was reported was blown final transistors: in many instances this was attributed to the operator's own carelessness. It is very likely that the 701 is the first solid-state rig ever owned by many of the Amateurs responding to this survey, and that fact may account for at least a few of the blown final transistors. There were also the usual sprinkling of assorted problems, including some cold solder joints, diode failures, and dirty switch contacts. Here are a few sample responses to the question, Have you had any problems with this rig?

"Cold solder joint. Had to return the rig to Dallas. This happened after six months of use." — WA2DXJ

"Output transistor failure in first few months, but corrected under warranty." — WB6LSP

"T/R switch section went bad and blew finals." — K7GCO

"Rf feedback with the eletret desk mike." — VE5YD

"Fan never worked from the day it was placed in line." — HP1XRK

"Antenna switching diodes shorted." — DJ4EI

"T/R switching diodes blew up." — DF2KT

"Finals failed when tuning up end-fed wire with tuner at full power. They were replaced at no cost with a caution to tune at reduced power." — K8EX

"Mode switch defective; intermittent CW reception." — NH6B

"None. In terms of maintenance, this has been the

table 3. **Problems. The percentage refers to the number of respondents who listed the problem on their survey form.**

	percent
no problems	37
blew final transistors	18
bad solder joints	5
other transistor problems	5
bad switch	3
bad capacitor	2
mike problems	2
drift	2
abnormally low output	1

table 4. **Accessories. The percentage refers to the number of respondents who bought the accessory in question.**

	percent
none needed	38
RM2 remote controller	27
EX1 extension terminal	17
tuner	10
keyer	9
desk mike	3

finest piece of equipment I've ever used." — K9BIL

"None! It gets almost constant use now and still no gremlins or breakdowns." — KB5AH

"Using the standard ICOM mikes I have had rf feedback problems when used with a linear amplifier. Bypassing and filtering have not helped." — WA5JXC

"Continual problem with the mode switch; have to switch and wiggle for good contact." — N7BZ

accessories and related findings

WB1CHY's response to the question, What accessories have you purchased for this rig?, was typical: "None needed. Everything needed comes as standard equipment — VFOs, mike, and power supply. Great!" It's not surprising, then, that 38 percent of those surveyed have never bought an accessory. Most of the Amateurs who did buy accessories bought either ICOM's RM2 remote controller (27 percent) or the EX1 extension terminal (17 percent). About 7 percent of those responding mentioned keyers, and some 6 percent had acquired a tuner. Three percent had purchased a desk mike.

To the question, Have you had the rig serviced?, 46 percent answered yes, 54 percent no. Of those who did have factory service, 85 percent found the service satisfactory. Eighty-four percent reported that they were able to obtain all the accessories and parts they needed, and 90 percent of those who had obtained accessories or parts found them satisfactory.

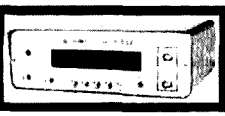
Among the 90 Amateurs who responded to the ICOM 701 questionnaire, there were only two Novices and one Technician. Fifty percent of those who replied held an Advanced class license, thirty percent held an Extra class ticket, and 18 percent were Generals.

The following twelve categories were scored from 1 to 10 (with 1 being poorest, 4 to 6 average, and 10 perfect): Ease of Operation, Reliability, Durability, Instruction Book, Factory/Dealer Service, Quality of Workmanship, Performance, Maintenance, Parts Availability, Accessories (ease of connection), Price, and Flexibility. The scores are reported in **fig. 1**.

would you buy one again?

Seventy-seven percent of those responding said that, yes, they would buy a 701 again. That's a very good showing, and one which demonstrates the ICOM 701 to be one of the most popular rigs we've covered in this series of owners' surveys. No one rig can satisfy everyone. But with 77 percent of the owners of ICOM 701s reporting that they would buy one again, it's clear that the ICOM people are doing something right. **ham radio**

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2304 MODEL #1 KIT BASIC UNIT W/PREAMP LESS HOUSING & FITTINGS ... $49.95
2304 MODEL #2 KIT (with preamp) ... $59.95
2304 MODEL #3 KIT (with High Gain preamp) ... $69.95

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ANTENNAS & OTHER ACCESSORIES AVAILABLE. SEND FOR MORE INFO

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NEW! **CLOCK KIT — HAL 79 FOUR-DIGIT SPECIAL — $7.95.** OPERATES ON 12-VOLT AC (NOT SUPPLIED). PROVISIONS FOR DC AND ALARM OPERATION.

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CLOCK CASE AVAILABLE AND WILL FIT ANY ONE OF THE ABOVE CLOCKS. REGULAR PRICE ... $6.50 BUT **ONLY $4.50 WHEN BOUGHT WITH CLOCK.**

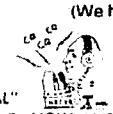
SIX-DIGIT ALARM CLOCK KIT FOR HOME, CAMPER, RV, OR FIELD-DAY USE. OPERATES ON 12-VOLT AC OR DC, AND HAS ITS OWN 60-Hz TIME BASE ON THE BOARD. COMPLETE WITH ALL ELECTRONIC COMPONENTS AND TWO-PIECE, PRE-DRILLED PC BOARDS. BOARD SIZE 4" x 3". COMPLETE WITH SPEAKER AND SWITCHES. IF OPERATED ON DC, THERE IS NOTHING MORE TO BUY * **PRICED AT $16.95**

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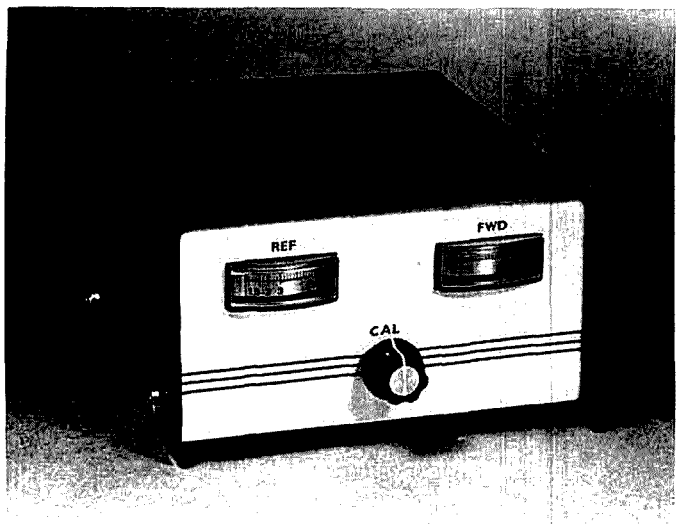
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SWR meter for the high-frequency bands

An easy-to-build SWR meter for beginner or old hand

The SWR meter, or standing wave ratio meter, is a small, self-contained device that provides an indication of the match — or degree of mismatch — between your transmitter and antenna system. The unit described here covers the high-frequency bands (80 through 10 meters) and is designed to operate with 50-ohm coaxial feedline, such as the popular RG-8 and RG-58 coaxial cable used in many Amateur installations. The sensitivity is such that it will operate well with most of today's transceivers in the 100+ watt class, and the unit can be left in the line for continuous monitoring of the system performance.

For ease of operation, two meters are employed in the design, thus allowing simultaneous readings of both the transmitter output and the reflected voltage without switching. A single control, used for calibration, is the only operator control on the SWR meter.

This SWR meter is ideal for the first-time builder, or for the casual builder who does not have a lot of special tools at his disposal. Common hand tools and a drill are about all that are required for the project. The construction is easy and the component count is low. The parts cost is also low. The completed unit measures 5 inches wide by 6 inches deep by 3 inches high (13 x 15 x 8 cm).

the circuit

The circuit of the SWR meter, as shown in **fig. 1**, has been in use among the Amateur community for many years and has been constructed in many different forms. The rf signal from the transmitter is applied to the SWR meter via the input jack J1. From J1, the signal travels along the coaxial-cable center conductor to the output jack J2, where it exits the metering package for the antenna feedline. Within

By Ken Powell, WB6AFT, 6949 Lenwood Way, San Jose, California 95120

the metering package we try to maintain the 50-ohm characteristics of the overall system, so as not to make the meter look like a "bump" or mismatch in the feedline system.

The two sense lines which parallel the coaxial-cable center conductor pick up a small portion of the rf signal, and this bit of the signal is rectified, filtered, and applied to the meters for monitoring purposes. Germanium diode CR1 and its associated sense line will pick up the incident or forward signal, rectify it, filter it with capacitor C1, and display the magnitude of this signal on the forward meter, M1. In a like manner, CR2 and its associated sense line will sample the reflected or reverse signal and present its magnitude on the reflected meter, M2. The sense lines and their associated circuits are identical but arranged in such a manner as to read the sampled voltage developed in the cable assembly in opposite directions. The use of two meters allows us to measure both of these samplings at the same time without the need for switching.

The calibration control R1/R2, which is a dual potentiometer, is used to maintain both metering circuits at the same level of sensitivity. This is necessary since the relationship of the forward and reflected meters must be constant. *In use, the transmitter is* keyed and the calibration control adjusted for a full scale reading on the forward meter. This adjustment of the control will set the same level of sensitivity on both meters, and the SWR, or percentage of reflected voltage, can be read directly on the reflected meter. The reflected reading represents the portion of rf voltage that has been applied to the feedline but has been reflected back from the antenna system due to mismatch.

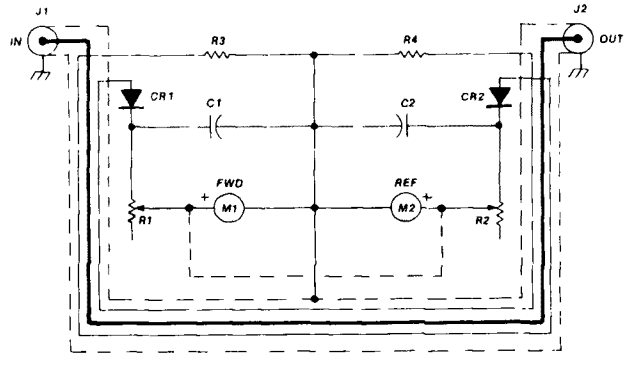
The setting of the calibration control will differ from band to band, because this type of sampling circuit is very sensitive to frequency and the rectified output will increase as the frequency of operation is increased. A few watts of rf will provide full-scale deflection of the forward meter on the 10-meter band, while approximately 60 watts will be required for full-scale deflection on the 80-meter band. This makes the circuit a natural for today's transceivers but makes it impractical for QRP rigs.

construction

The construction of the SWR meter makes it ideal for the first-time builder. The values of the components used are not overly critical, nor can they be damaged as easily as solid-state devices. The rf circuits are sometimes critical, but the SWR meter allows quite a bit of leeway in construction. Standard hand tools and a drill will get you started and, as the case specified in the parts list is made of a soft-grade of aluminum, the mechanical portion of the project is quite easy. A bit of filing is necessary for the rectangular meter cut-outs, but the remainder of the sheet-metal work is accomplished with a drill. I did a bit of sanding and painting on the unit pictured, but that's not essential.

The heart of the SWR meter is the coaxial-cable sampling assembly, illustrated in **fig. 2.** This cable assembly is formed with RG-58/U coaxial cable, and the completed dimensions for the assembly are shown *in* the illustration. Begin construction of the assembly with the 24-inch (61-cm) length of coax; we will trim it down to size as construction progresses. Remove the entire outside jacket of the coax by cutting it the long way with a hobby knife. With the outside jacket removed, expand the diameter of the shield (braid) slightly by pushing the braid toward the center from each end. This slight expansion of the shield will aid in the easy removal of the center conductor complete with its insulation.

Using No. 24 or No. 22 AWG (0.5 or 0.6 mm) solid wire, cut two lengths approximately 24 inches (61 cm) in length to form the sense wires. Two different colors should be used to aid *in* identification. Cut the coax braid to a length of 16 inches (41 cm) and insert

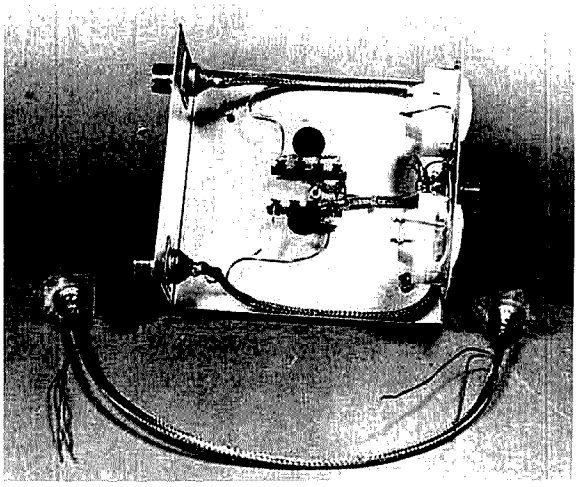


C1, C2	0.005-μF disc capacitors
CR1, CR2	1N34A diodes
J1, J2	UHF connector SO-239 and Hood UG-1771U Amphenol No. 83-1R and 83-765
M1, M2	200-μA meters, Calectro No. D1-907
R1, R2	dual potentiometer, 100 kilohm, Radio Shack No. 271-224
R3, R4	51-ohm carbon resistors
case	5¼x3x6 inches (13.3x7.6x15.2 cm) Radio Shack No. 270-253
knob	0.750x¼ shaft diameter Radio Shack No. 274-415
misc.	wire, solder lugs, small hardware, lettering material

A kit is available from RADIOKIT, Box 411, Greenville, NH 03048-0411.

fig. 1. Schematic diagram for the SWR meter.

the two sense lines into the braid, leaving an equal amount of wire protruding from each end. Bend the excess length of the sense wires over the ends of the braid so the sense wires will not fall out. Now, feed the coax center conductor back into the braid with the sense wires installed. It is easy to manipulate the diameter of the braid by compressing it along its length, and the center conductor should reinstall easily.



Interior of the SWR meter showing component layout. The sampling assembly (foreground) was made from RG-58/U coaxial cable.

After the center conductor is in place, stretch the braid to its normal length to restore it to its original diameter, making it look like a 50-ohm device again. This operation should leave an ample amount of the center conductor and sense line exposed at each end of the braid. The assembly should now begin to resemble that of fig. 2.

With a hobby knife or awl, start a small hole in the braid approximately 1 ½ inches (40 mm) from the end of the braid. To form this opening in the braid, don't cut the braid but rather start an opening where the braid windings intersect and expand the size of this opening by compressing the braid from the end. Now manipulate the sense wires within the braid until the ends of the sense wires are visible through the hole in the braid. Fish the sense lines out of the braid through the hole and leave approximately 4 inches (10 cm) of the sense line exposed, as in fig. 2. Fold the sense lines back so they are not pulled out of the assembly accidentally.

The hood, a UG-177/U fitting, can now be soldered to the coaxial cable braid. Prior to soldering the hood, pull the cable center conductor back toward the other end of the cable for a distance of 2 inches (5 cm) or so. In this manner, if the center conductor insulation gets a bit warm during the soldering operation the damaged portion can be cut from the cable when it is fitted to the UHF connector. When you have finished the first end of the cable assembly, the sense lines and the hood can be completed similarly for the other end of the coax assembly. When the assembly is complete, stretch the braid out again to restore the original diameter and check the assembly against fig. 2. If it is reasonably close, you can put it aside and start on the case.

the case

If you use the case shown in the parts list, or one of similar dimensions, you can follow the general layout seen in the photo. The front panel requires two rectangular cut-outs be made for the meters and a single hole for the calibration control. The rear panel requires holes for the UHF connectors, and a single hole is needed for mounting the two solder lugs that support the diodes, resistors, and capacitors that form the metering circuit. After you've checked all the case-mounted components to make sure they'll fit, the case may be sanded lightly with 320 paper and a couple of coats of spray lacquer applied. While the case is drying we can do a little modification on the two meters.

the meters

The meter assemblies are held together with transparent tape and can be disassembled easily. The meter scales are held in place by two tabs that are parts of the meter face. These two tabs may be straightened out and the meter faces removed for modification. Gently flatten the meter face out and,

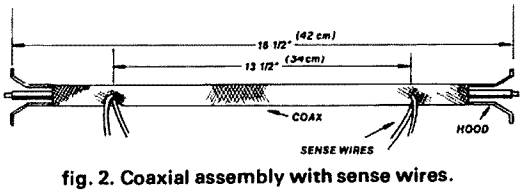


fig. 2. Coaxial assembly with sense wires.

using a typewriter eraser, remove all the printed words from the meter faces, leaving only the scales, which consist of 20 divisions.

Using rub-on lettering, modify the meter faces as in fig. 3. The lettering kit used for this purpose was Letraset K19/5, which is a meter lettering set containing both red and black materials. All the lettering on the SWR meter was done in black with the exception of the horizontal line on the reflected meter that

extends from the center of the meter scale to the right edge, or full scale position. This was done in red to remind me to keep things in the system under 3:1. When the meter scales are complete, a light coating of clear spray will lend a professional finish to them. After they have dried, the scales can be reinstalled on the meters and the assemblies held in place with transparent tape.

The front and rear panels can now be lettered with rub-ons, and, if desired, the racing stripes may be added by using *Prestape*, available at art supply stores. A coating of clear spray will protect the lettering and level out the finish on the case. I mounted the meters to the case with a dab of epoxy at each of the two mounting ears, to avoid more holes on the front panel. After components have been mounted to the case, the wiring should be completed as in the schematic diagram. The photo of the interior of the unit will assist you with wire routing and general layout. The center conductor of the coax is trimmed to size and wired to the UHF connectors; the hoods are put in place using the UHF connector mounting hardware.

As shown in the diagram, the common, or ground

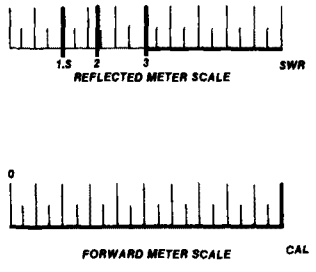


fig. 3. Modified meter scales.

portion, of the circuit is connected to the shield of the coaxial cable assembly at the approximate center of the assembly. In turn, the cable assembly is connected to case-ground via the hood assemblies at the UHF connectors. These are the only connections to the case of the SWR meter. When the wiring has been completed, the case can be closed, the calibration knob installed, and the unit is ready for testing.

testing and use

To test the SWR meter, connect your transmitter output to J1 using 50-ohm coaxial cable. The antenna feedline is connected to J2. Key the transmitter and adjust the calibration control for a full-scale reading on the forward meter. Note the SWR reading on the reflected meter at this time. Next, transpose the input and output leads on the SWR meter. Now the transmitter will be feeding the output jack J2, and the antenna system will be connected to J1. If the sense lines and their associated circuits are working well, the readings on the two meters will be transposed. The reading noted on the reflected meter will now be displayed on the forward meter. If this condition approximates your results, both the sampling circuits have the same sensitivity and the input and out cables can be returned to their normal positions. The SWR meter is now ready to go to work on your antenna systems, checking operation of the system and assisting you in tuning the system to your favorite spot on the band.

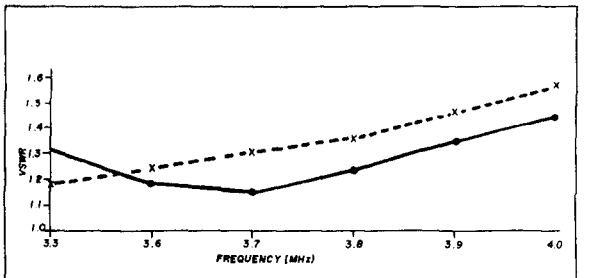


fig. 4. SWR readings for 80-meter band.

I made the graph in fig. 4 for checking the operation of my 80-meter dipole antenna. Initially, the lowest SWR reading was found at the lower limit of the band and the SWR increased with frequency. This indicated that the dipole elements were a bit too long and a little pruning eventually led to the second reading indicated by the solid line in fig. 4. Now the resonant point is at 3.7 MHz and the SWR is well within reason on both the CW and phone segments of the band. Remember, if resonance is at the high end of the band the antenna elements are short; resonance at the low end means elements are long. In this manner, you can really get a good idea of what your system is doing and get things tuned for the highest efficiency. In tuning a multiband antenna system, such as a trap dipole, start with the highest frequency band and work your way down in frequency. Once you are satisfied that the antenna system is working well, the SWR meter can be left in the line if desired to provide a constant indication of transmitter output and antenna resonance.

In conclusion I would say that the SWR meter is a good project for the newcomer or the old-timer getting back into the swing of home brew, and, while I would not call it a lab instrument or anything even close, it is a handy device for keeping your antenna system humming.

ham radio

locating geostationary satellites

Calculator program for solving basic equations

Satellite tracking is becoming very much a part of Amateur Radio. The OSCAR program is alive and well. AMSAT is strong. The future for the Amateur space community looks good. A geostationary Amateur satellite, tentatively named SYNCART (for SYNchronous Canadian Amateur Radio Transponder), is in the works. This spacecraft, which is on the drawing board, will be launched into geosynchronous orbit. This means that SYNCART will be at an altitude of about 22,500 miles (36,225 km) and will be on station over the equator.

This article provides information for locating *any* geostationary satellite, given basic geometric data, using a popular handheld calculator. **Editor.**

By using an inexpensive calculator, such as the Texas Instruments TI58 (or TI59), the look angle (relative to true north) and elevation angle may be determined easily from any point on the globe to any geostationary (fixed) satellite. The only requirements are that the latitude and longitude of the earth station must ba known, and the longitude of the satellite must be known. (They are listed later in this article.)

The program takes eight minutes to load and check; fifteen seconds to run. The results, relative to true north, may be used directly or put in terms of magnetic north through correlation with the declination angle, as shown on topographical maps.

basic equations

The calculator program uses the following basic equations:

$$Az^\circ = 180 + \tan^{-1}\left(\frac{\tan\theta}{\sin\alpha}\right) \qquad (1)$$

where Az° is the look angle of the earth station relative to true north (azimuth)

θ is the relative longitude between the earth station and the satellite (earth-station longitude-satellite longitude)

α is the earth-station latitude

$$El^\circ = 90 - T - R \qquad (2)$$

where El° is the elevation angle looking at the satellite, and

$$R = \cos^{-1}(\cos\theta\cos\alpha)$$

$$T = \tan^{-1}\left(\frac{\sin R}{6.6166 - \cos R}\right)$$

running the program

After the program has been entered into the calculator, data may be entered and the equations solved:

Earth-station latitude (in degrees, minutes, seconds): **STO 00.**

Earth-station longitude (in degrees, minutes, seconds): **STO 01.**

By Walter E. Pfiester, Jr., W2TQK, 1 Skadden Terrace, Tully, New York 13159

program

key		step	code	comments	key		step	code	comments
LRN	RCL	000	43		2ND	COS	030	39	
	02		02	spacecraft longitude		X		05	
	−		75			RCL		43	
	RCL		43			06		06	
	01		01	earth-station longitude in DMS	2ND	COS		39	
						)		54	
2ND	DMS		88	earth station in decimal		INV		22	
	=		95		2ND	COS		39	
	STO		42			STO		42	
	05		05			07		07	
2ND	TAN		30		2ND	SIN	040	38	
	÷	010	55			÷		55	
	RCL		43			(		53	
	00		00	earth-station latitude in DMS		6		06	
2ND	DMS		88	earth station latitude in decimal		•		93	
						6		06	
	STO		42			1		01	
	06		06	latitude stored		6		06	
2ND	SIN		38			6		06	
	=		95			−		75	
	INV		22			RCL	050	43	
2ND	TAN		30			07		07	
	+	020	85		2ND	COS		39	
	1		01			)		54	
	8		08			)		54	
	0		00			INV		22	
	=		95		2ND	TAN		30	
	STO		42			+/−		94	
	03		03			−		75	
	R/S		91	azimuth relative to true north (answer)		RCL		43	
						07	060	07	
	RCL		43			+		85	
	05		05			9		09	
						0		00	
					STO	=		95	
						04		42	
						R/S		04	end of program, elevation (answer)
						LRN	067	91	brings calculator out of program mode

Spacecraft longitude (in decimal form): **STO 02.**
Then, reset the program: **RST R/S** calculates antenna azimuth relative to *true* north. Pushing the **R/S** button a second time results in the antenna elevation.

example

42.48	04	**STO 00**
76.06	37	**STO 01**
135.0		**STO 02** *(location of* RCA SATCOM 1*)*
RST R/S		247.704° azimuth: **R/S** 13.839° elevation

Should the answer for elevation angles be negative, the satellite is below the horizon and is not in a position to be viewed by the earth station.

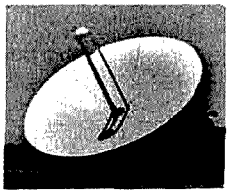
additional program notes

For locations south of the equator, change the following program steps: 21, 22, 23 from 180 to 360.

register notes:

register	use
00	earth-station latitude
01	earth-station longitude
02	spacecraft longitude
03	azimuth
04	elevation
05	del longitude (used later)
06	earth-station latitude, later reused, scratch-pad memory

For satellites located at east longitude, enter as a negative number (−) in register 02. No other program changes need be made.

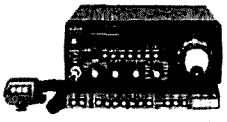


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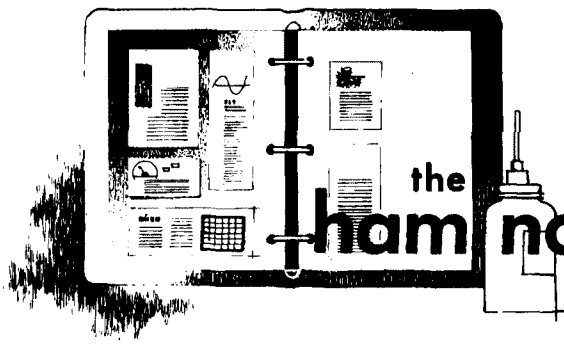
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locations of nonmilitary geostationary satellites

satellite	location (degrees east longitude)
GOES 2	0-35
OTS	10
RADUGA 3	35
RADUGA 4	35
SYMPHONIE 2	49
INTELSAT IV F5	57
INTELSAT IVA F3	60.2
INTELSAT III F3	65.3
MARISAT	73
PALAPA 2	77
RADUGA 2	80
RADUGA 1	80
INDOSAT	80
PALAPA 2	83
MOLNIYA 1S	90
EKRAN 1	99
EKRAN 2	99
KIKU 2	135
HIMAWARI	140
INTELSAT IV F8	174
INTELSAT IV F4	179
MARISAT 1	176.5
METEOSAT	0
INTELSAT IV F7	1
INTELSAT IV F7	6.4
SYMPHONIE I	11.5
STATIONAIR 4	14
MARISAT II	15
SIRIO	15
INTELSAT IV F1	18.5
INTELSAT IV F3	21.7
INTELSAT IVA F1	24.5
INTELSAT IVA F4	34.5
ATS 5	70
SMS 2	75
GOES 2	75
WESTAR V	79
WESTAR III	91
COMSTAR D2	95
WESTAR I	99
ANIK III	103
SMS 1	105
ATS 3	105.6
ANIK II	109
ANIK IV	109
ANIK I	114
CTS	116
SATCOM II	119
WESTAR II	123.5
COMSTAR D1	128
SATCOM 1	135
GOES 3	135



a "free" RTTY tuning indicator

A free lunch may be hard to come by, but here's a trick for getting a simple tuning indicator on a radioteletype demodulator without any increase in the parts count.

As shown in fig. 1, in my RTTY terminal unit I use a conventional active filter tuned midway between the mark and space frequencies, and a diode clipper to limit the signal. The unconventional part is the use of LEDs instead of ordinary diodes for the clipper. One of the LEDs is mounted on the front panel of the terminal unit where it can be seen as the receiver is tuned.

As the receiver is adjusted to produce the desired 2125- and 2295-Hz tones from an FSK signal, the LED will start to flicker as the correct adjustment is approached. When the two tones straddle the peak frequency of the filter the LED will appear to be steadily lit. Any drift in the receiver or transmitter will be revealed by the reappearance of flickering. The human eye is quite sensitive to the flicker that results from normal Amateur baud rates, and this is a surprisingly effective aid to tuning. Of course, selective fading will also cause the LED to flicker, but one can quickly learn to use both eyes and ears to interpret what is happening.

By using LEDs to limit the RTTY signal after it passes through a 2210-Hz bandpass filter, the limiting action is made visible, and proper tuning is indicated by minimum flicker. Proper action depends on a relatively broad filter response, so component values are not critical. Those shown were what were available and close to calculated values. The first section of the filter shown here is a 2000-Hz highpass filter to increase the rejection of lower audio frequencies; the idea described here will work without this section, but the system will be more vulnerable to interference.

A.S. Woodhull, N1AW

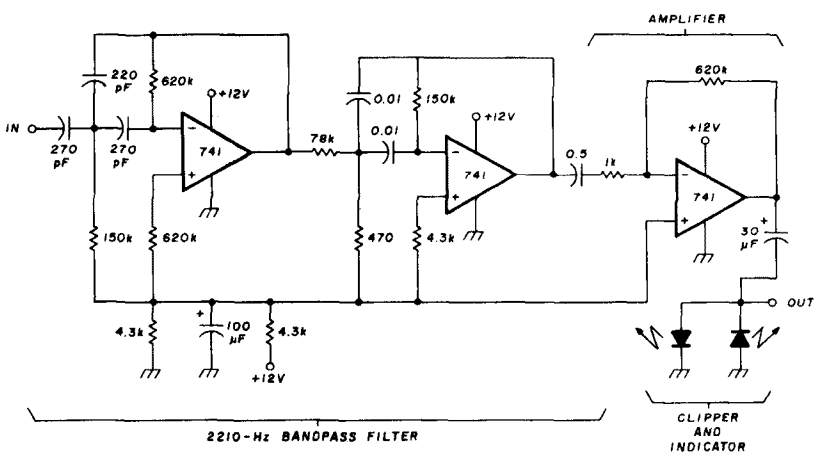


fig. 1. Diagram for RTTY tuning indicator.

light-bulb dummy loads

Light-bulb dummy loads have been used for transmitter testing since the beginning of Amateur Radio. Light bulbs can harmlessly dissipate lots of rf power, and they give a visual indication of approximate power output.

But, as dummy loads, they have two major shortcomings: they are inductive, and their resistance depends on the power level. When checked with an ohmmeter, the cold resistance will usually measure less than 1/10 the full-brilliance resistance. The inductance of a typical 100-watt, 120-

volt bulb is in the vicinity of 1/2 microhenry. At any given frequency this inductance can be tuned out by series resonating it with a capacitor of equal reactance.

Fig. 2 shows an experimental 200-

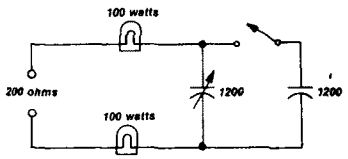


fig. 2. The 1200-pF variable is a three-gang, 400 pF-per-section unit with the stators connected in parallel.

watt, 200-ohm balanced dummy load used to test a 4:1 flyback balun. By adjusting the series capacitor and power level it was possible to obtain a 1:1 SWR on any band, 80 through 10 meters. Theoretically, the bulb resistance should be 288 ohms at full brilliance, which would be an SWR of 1.44 on 50-ohm coax when measured through a 4:1 balun. This, in fact, is what it measured. An SWR of 1.0 was observed at about the 100-watt level, and remained below 1.4 from 50-200 watts.

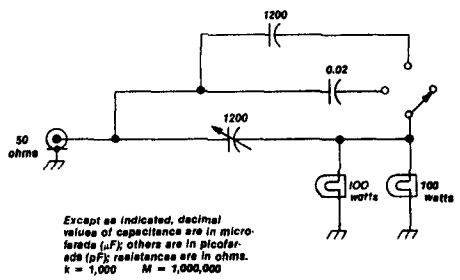


fig. 3. The 1200-pF variable is the same as in fig. 1. The switch is a three-position rotary type.

Fig. 3 shows a 50-ohm version of this load, usable from 50-200 watts on all bands, with an SWR below 1.4.

Series and parallel combinations of light bulbs of suitable wattage ratings can be combined to construct a dummy load of any power capacity with the low SWR so long as the inductive reactance is tuned out with a series capacitor.

Fredrick W. Brown, Jr., W6HPH

dipole antenna length reference chart

Here's a handy reference chart if you're thinking about putting up a dipole for one of the new or old ham bands. Using the formula $L\ (feet) = 468/f\ (MHz)$, the length will be correct for practical purposes, and you can prune the antenna later if necessary.

frequency (kHz)	length ft. (ft. × 0.305 = meters)	in.
1,800	260	0
1,820	257	1
1,860	252	11
1,875	249	6
1,900	246	4
2,000	234	0
3,500	133	8
3,600	130	0
3,700	126	6
3,800	123	0
3,900	120	0
4,000	117	0
7,000	66	10
7,050	66	5
7,100	66	0
7,150	65	6
7,200	65	0
7,250	64	7
7,300	64	1
10,000	46	10
10,100	46	1
10,200	45	11
10,300	45	5
10,400	45	0
10,500	44	7
14,000	33	5
14,100	33	2
14,200	32	11
14,300	32	8
21,000	22	4
21,100	22	1
21,200	22	0
21,300	21	11
21,400	21	10
24,500	19	1
24,600	19	0
24,700	18	11
24,800	18	10
24,900	18	9
25,000	18	8
28,000	16	8
28,100	16	7
28,200	16	6½
28,300	16	6
28,400	16	5½
28,500	16	5
28,600	16	4
28,700	16	3½
28,800	16	3
28,900	16	2½
29,000	16	2
29,100	16	1

Many of the new transceivers now have all of the new band crystals installed. You might as well be listening to shortwave broadcasts with a dipole antenna and using the positions until the bands open!

Ed Marriner, W6XM

data retrieval program using the APPLE II computer

One day I was talking to KN5KSQ on 40 meters and he mentioned that we had worked each other once before. I scanned my log quickly but couldn't find KN5KSQ. Then the band went out before I could get more specific information.

Haunted by the fact that we had worked before, I started searching through my logs and lo and behold! There it was: one of my first contacts.

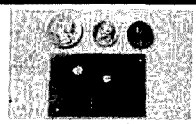
I pondered the situation and stared at my station, which included an APPLE II computer with a tape recorder. I decided I needed a data-retrieval program that's short (for maximum RAM storage), provides fast search of two or three fields, prints all items on the monitor in an easy-to-read format, and provides easy data entry. I found such a program and revised it to run on disk or tape. I now have a disk drive and use the APPLE II for log-data retrieval as well as send/receive SSTV, CW, RTTY, and ASCII — all done with software provided by C.H. Galfo, WB4JMD.

I have over 650 log entries, and it takes about 28 seconds to search all of them. The program is set up to hold 1000 entries or less, depending on RAM size, and the program can be easily modified to suit your needs. I'll be glad to supply a copy of the program. Send a self-addressed stamped envelope with 28¢ postage to WB6YHS, 1220 Vienna Drive, No. 715, Sunnyvale, California 94086.

It's nice to have the capability of quickly finding data on former radio contacts. Another use of the APPLE III!

Charles M. George, WB6YHS

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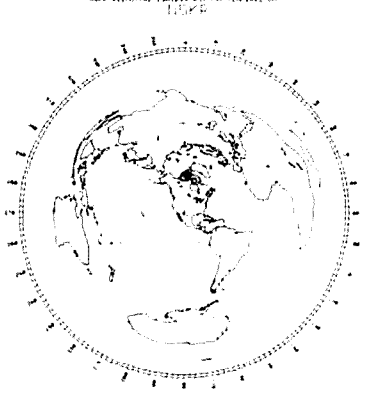
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CONNECTICUT: The SCRAMS and Tri-City Amateur Radio Clubs of Groton are co-sponsoring an auction, Saturday, October 24, 10 to 4, St. Mary's Parish Hall, Groton. Talk-in on 07/67 or 34/94. Admission free. 10% of proceeds to be donated to the two radio clubs. For further information: Anne Hibbert, WB1GVL, 64 Giant's Neck Road, Niantic, CT 06357. (203) 739-4970.

INDIANA: The Hoosier Hills Ham Club's annual Hamfest, Sunday, October 11, Lawrence County 4-H Fairgrounds, just south of Bedford. Refreshments, flea market, door prizes, vendors, free camping available. Grand prize: Azden PCS-3000. Raffle prize: TRS 80 Mod. III 4KL1 computer. Admission: $3.00. Talk-in W9QYQ, 146.13/73. For further information: HHHC, P.O. Box 891, Bedford, IN 47421.

MASSACHUSETTS: The Framingham Amateur Radio Association's 6th annual Fall Flea Market, Sunday, October 25, Framingham Police Station drill shed. New England's largest Indoor Ham Flea Market. Doors open 10:00 AM. Sellers setup 8:00 AM. Admission: $1.00. Sellers $8/table prior to October 15; $10/table after October 15. Talk-in on 75/15 and 52 direct. Contact: Ron Egalka, K1YHM, 3 Driscoll Drive, Framingham, MA 01701. (617) 877-4520.

MASSACHUSETTS: The Wellesley Amateur Radio Society's tailgate flea market, Saturday, October 10, 9 AM, Wellesley High School, 50 Rice Street, Wellesley Hills, off Route 16. Admission: $1.00 per person, buying or selling. Talk-in on 147.63/03. For information: Nels Anderson, K1UR, (617) 323-5029.

NEW YORK: The TuBoro ARC will hold a mini Flea Market and Auction, Sunday, October 28, 9 AM to 4 PM, Odd Fellows Hall, 149-14 - 14th Avenue, Whitestone. Admission: $1.00 donation. For information and table space: Marty (212) 359-6923 after 7 PM, or Ed, WB2IBQ, (212) 746-4080 after 7 PM. Talk-in on 145.62 simplex.

OHIO: The Marion Amateur Radio Club's 7th annual Heart of Ohio Ham Fiesta, Sunday, October 25, 0800 to 1600, Marion County Fairgrounds Coliseum. Door prizes,

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YAESU FT-901/902. See "73", Sept. 1981
HEATH SB104A See "Ham Radio", April 1981
KENWOOD TS820 See "CQ", March 1981

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PENNSYLVANIA: The Irwin Area Amateur Radio Association's Swap & Shop, Saturday, October 17, Circleville V.F.D., Robbins Station Road, Irwin. Flea Market, prizes, vendors, food, free parking. Talk-in on 146.925/.325 and 146.52 MHz. For further information: Bill Stash, WA3AQQ, 421 Dalley Drive, N. Huntingdon, PA 15642.

PENNSYLVANIA: The R.F. Hill ARC's 5th annual Hamfest, November 8, Sellersville National Guard Armory, Sellersville. Doors open 7 AM, sellers; 8 AM, buyers. Talk-in on 28/88 and 52. Grand prize, door prizes, refreshments. For information: R.F. Hill ARC, Box 29, Colmar, PA 18915 or Chet Pierson, K3TV, Box 336, RFD 1, Greenlane, PA 18054.

PENNSYLVANIA: Symposium on Small Computers in the Arts, November 20-22, University City Holiday Inn on the Penn campus, Philadelphia. Tutorials, workshops, demonstrations, presentations, film/video showings and the 4th Annual Computer Music Concert. Sponsored by: Philadelphia Area Computer Society, University of Pennsylvania, the IEEE Computer Society and IEEE Philadelphia Section. For information: Symposium on Small Computers in the Arts, Box 1954, Philadelphia, PA 19105 or call Philadelphia IEEE office. (215) 243 6109.

PENNSYLVANIA: The Foothills ARC's annual Swap & Shop, Saturday, November 7, St. Bruno's Church, South Greensburg. 9 AM to 3 PM. Registration $2.00 each or 3/$5.00. All indoor facilities. Main Prize: Kenwood TS-530S HF Rig. First Prize: Icom IC-2A Handheld. Talk-in on 146.07/.67 and 146.52 simplex. For advanced table reservation: Chuck Hamman, WB3HZM (412) 637-9194 after 5 PM.

TENNESSEE: The Mid-South Amateur Radio Association, the Memphis VHF Club, Raleigh ARA and Delta ARC will hold the Memphis Hamfest, October 10 and 11, Memphis Fairgrounds Youth Bldg. (same as last year), 8 AM to 4 PM Saturday and 8 AM to 2:30 PM Sunday. Admission: $3.00, under 14 free. Motel accommodations nearby. Indoor/outdoor Flea Market. ARRL Forum, ladies' activities, DX forum, Antenna forum, computer displays and Amateur Radio related forum. FCC exams pending at this time. Dance with snacks in Hamfest area Saturday night. For details: Memphis Hamfest, 28 North Cooper, Memphis, TN 38104 or Call Clayton Elam, K4FZJ (901) 274-4418 days; (901) 743-6714 nights. Howard Smith, WD5DVB, M.A.R.A. President (901) 372-9618. Talk-in on 34/94 and 52 simplex.

OPERATING EVENTS
"Things to do..."

OCTOBER AND NOVEMBER: DXpeditions to NIUE Island. Five members of the Northern California DX Club will operate from Niue Island (ZK2) for both the CQ WW phone and CW contests. WB6EXW and WA6AHF will operate October 21-29, and K6RU, AA6AD, and N6HR, November 25-December 3. License arrangements are complete but call signs will not be known until arrival on Niue. Operation on all bands 10m-160m with emphasis on low bands during non-contest periods. QSL via: The Northern California DX Club, Inc., P.O. Box 608, Menlo Park, CA 94025.

OCTOBER 3 & 4: The Parkersburg ARK of West Virginia's in-state DXpedition to the top of Spruce Knob, the highest mountain point in West Virginia, Randolph County. Starts 1500 UTC. Station call N8CDD. Listen 52.150 and 52.5225 MHz and 144.2, 144.19, and 144.11 MHz. For special QSL send SASE to N8CDD, 902 23rd Street, Vienna, VA 26105.

OCTOBER 10 AND 11: The Jefferson County ARC, DeSoto, MO, will be operating a special events station, KA9IAR, commemorating the Population Center of the U.S., as determined by the 1980 census, from 1700 GMT, October 10 to 1700 GMT, October 11. Approximate frequencies: 25kc up from bottom edge of General portions of 10, 15, 20 and 40 meters; and center of Novice portions. For certificate: SASE with OSL to: KA9IAR, 3009 High Ridge Blvd., High Ridge, MO 63049.

OCTOBER 10, 11: 9 Land OSO Party. Starts 1800 UTC, Saturday, October 10; ends 2359 UTC, Sunday, October 11. Suggested frequencies: CW, 1805, 3560, 7060, 14060, 21060, 28060 + VHF. SSB, 1815, 3895, 7230, 14280, 21355, 28800 + VHF. Novice, 3725, 7125, 21125, 28125. Certificates awarded to top score in each state, province and ARRL country. For further information: SASE to Ill Wind Contesters c/o John W. Sikora, WB9IWN, 8747 Northcote, Munster, IN 46321.

OCTOBER 10-12: The Southern Sierra ARS, Tehachapi, is conducting a dual-site expedition using K6RL from Badwater, Death Valley, and the summit of Mount Whitney, California, during the Columbus Day weekend. 1900 UTC October 10 to 0100 UTC October 12. Modes: CW QRP 21.105 or 28.105, 7.105 MHz. Two CW stations will be operating on different bands. 2-meter FM on 146.550 MHz simplex. The Badwater station will operate from 1900 UTC October 10 to 1900 UTC October 11 on CW ±21.100 and 7.110 MHz. For a commemorative certificate confirming your QSO, send QSL and $1.00 to SSARS, Rt. 2, Box 338, Tehachapi, CA 93561.

OCTOBER 13, 14, 15: The Colquitt County Ham Radio Society will be operating club station WD4KOW from the fourth annual Sunbelt Agricultural Exposition. 0900 to 1600 EDST each day. The Sunbelt Expo, Spence Field Airbase near Moultrie, Georgia, is the largest agricultural show in the south. Operations on 40 and 20 meters around 7.250 and 14.300 MHz with some in the other HF bands. Visiting Hams listen on local repeater 146.19/79. Visit the amateur booth at the Expo and operate the Amateur station. Receive a special QSL card for contacts.

OCTOBER 16, 17, 18: The Stark RTTY Group, WB8RVM, will be operating a special event station at the Mellet Mall Hobby Show, Canton, Ohio, to demonstrate Amateur Radio to the general public. Modes and frequencies: SSB, 5 kc up from low end of general portions of 80 thru 10 meters; CW, 3540, 7040, and 14.060. RTTY on 14.090 and 3620. Local contacts on 146.52 MHz. From 1400 to 0100 GMT, October 16 and 17. From 1400 to 2200 GMT, October 18. A special certificate awarded to all Amateurs contacted during this period. Send QSLs and SASE (9 × 11) to: The Stark RTTY Group, WB8RVM, 138 Page Street N.W., Massillon, OH 44646.

OCTOBER 17: 27th Annual VHF Conference, Kohrman Hall, Western Michigan University, Kalamazoo, MI 49008. This is a technical conference for Amateurs and Radio Engineers. For further information: SASE to Western Michigan University, Department of Electrical Engineering, Kalamazoo, MI 49008. Att: Dr. Glade Wilcox, W9UHF.

OCTOBER 17, 18: QRP Amateur Radio Club's International CW QSO Party. From 1200 UTC, Saturday, October 17 to 2400 UTC Sunday, October 18. Suggested frequencies: 1810, 3560, 7040, 14060, 21060, 28060, 50380. Any VHF/UHF contacts must be direct, no repeaters. Novice frequencies: 3710, 7110, 21110, 28110. Call: CQ QRP de *Call Sign*. For further information: SASE to QRP ARCI Contest Chairman, William W. Dickerson, WA2JOC, 352 Crampton Drive, Monroe, MI 48161.

OCTOBER 21 & 22, NOVEMBER 4 & 5: YL ANNIVERSARY PARTY. All licensed women operators worldwide are invited to participate. CW, Wednesday, October 21, 1800 UTC to Thursday, October 22, 1800 UTC. Phone: Wednesday, November 4, 1800 UTC to Thursday, November 5, 1800 UTC.

OCTOBER 24 AND 25: The Wiesbaden Amateur Radio Club's second Contest DXpedition to Luxembourg in conjunction with the CQ Worldwide Phone DX contest. Call sign, DA1WA/LX. Operations on all bands, 10 through 80 meters. Stateside QSLs, SASE to Steve Hutchins, Box 4573, APO New York 09109. Other QSLs to DS0LC, Dr. Hugo Jakobljevich, Am Weinberg 10, 6200 Wiesbaden-Auringen, West Germany. For further information: Steve Hutchins or Claude Matchette, HHC, V Corps (G-2), APO New York 09079.

SAY YOU SAW IT IN ham radio!



ETS Morse-code training package

Many methods have been offered for learning Morse code, some good and some not so good. This is a good one. We at *ham radio* have had an opportunity to study the Morse-code training package by Educational Technology and Services, Incorporated (ETS). This training package is not just an ordinary collection of code tapes that progress from low to high speed. The training method is based on scientific principles — a Perceptual Learning Model developed at the University of Minnesota and from research conducted at Southern Illinois University and at the Research and Development facility of ETS.

It has been found that, when using conventional Morse-code teaching methods, students progress to a speed of 10-13 WPM, at which point they reach a plateau. From then on, learning to copy code at higher speeds becomes more difficult. This plateau results from the shift from one method of copying, in which the student must analyze the code character, to another method in which the student begins to perceive the code character. ETS studies have resulted in the identification of the variables that contribute to the plateaus experienced in the Morse-code learning process and have developed a concept that eliminates the problems associated with traditional Morse-code training programs.

With the ETS package, the entire alphabet can be learned in 25 trials. The letters are presented at, and spaced at, 18 WPM. Now this may scare you off — whoever heard of starting to learn Morse at 18 WPM? That's where the ETS perceptual learning concept comes in. You learn to recognize, and translate to paper, letters and words not at, say, 5 WPM with gradually increasing speed, but at 18 WPM from the very beginning. Trial number one starts you off with two letters randomly presented. Each successive trial adds a single letter until the entire alphabet is learned. When the last trial is mastered, the entire alphabet can be copied at 18 WPM. The method allows you to master the code in 40 percent less time than conventional Morse-code instruction techniques.

The ETS Morse-code training package consists of four phases:

1. Twenty-six letters of the alphabet
2. Numbers
3. Punctuation and special characters
4. Plain text practice

The ETS Morse-code training package, consisting of five cassettes (6½ hours total practice) is available at Ham Radio's Bookstore for $18.95. — *ham radio* staff.

MFJ CW/SSB/notch filter

All modern receivers have more than adequate filtering capabilities. However, despite all the fancy filters available, there are still those of us who need more help. MFJ, long known as the supplier of add-on accessories, has designed an excellent outboard audio filter: the MFJ 722 Signal Optimizer. Using the latest chip technology, the Signal Optimizer design includes a tunable notch filter and selectable high-pass/low-pass filter on SSB, and a bandpass filter on CW.

Hookup and installation of the 722 is simple and straightforward. The receiver audio is routed through the filter and back to the speaker. A 1/4-inch (6.4-mm) jack is included in the filter so you can use headphones should you prefer. The only other connection is to provide 12 volts dc to the filter. Signal Optimizer design allows ease of use under any operating situation.

As with every new piece of equipment, there is a learning curve associated with using the filter. The 70-dB notch filter is a bit tricky to use at first. But MFJ's operating manual clearly explains the tricks of using the notch, and that complete explanation eliminates any problem you might have.

When filtering in the SSB mode, the 722 attenuates all the high and low frequencies. In the high-pass position, all signals below 375 kHz are efficiently eliminated. When switched to 2.5, 2 and 1.5 kHz a low-pass filter is engaged in progressively narrower units to achieve desired filtering.

On CW, the Model 722 uses an active IC bandpass filter of progressively narrower windows. One problem that has occurred before with some outboard filters is that the narrower the filter becomes, the more it tends to ring or give you the impression you are listening through a pipe. The MFJ 722 has no ring.

During many hours of use, both in casual rag chewing and DXing, the Model 722 filter has been quite a nice addition to the shack. A real test comes each summer with 160-meter QRM.

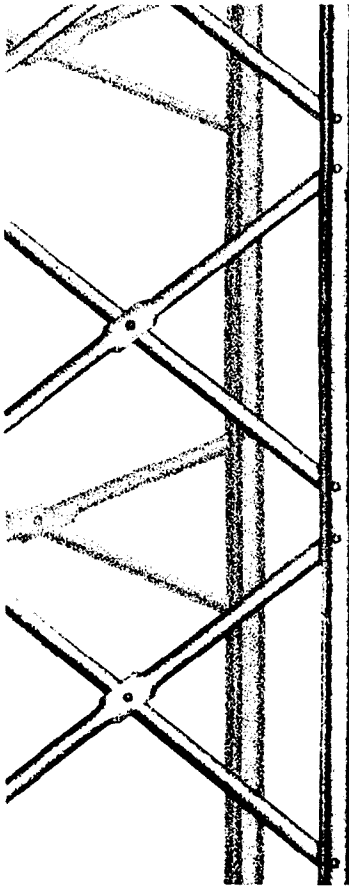
The MFJ Signal Optimizer measures 5 × 2 × 6 inches (13 × 5 × 15 cm) and sells for $69.95 plus shipping. A 12-volt dc power supply is also available for $7.95 plus shipping. For more information write MFJ Enterprises, Box 494, Mississippi State, Mississippi 39762.

wire cut and strip tool

A new concept for easy and clean stripping of wires for wire-wrapping, electronic, and appliance applications, the ST-100 strips without nicking and automatically generates the proper strip length. Biomechanically designed for maximum efficiency, its slim design makes it ideal for storage in pocket, belt holder, or tool kit.

Simply place wires (up to four) in stripping slot with ends extended beyond cutter blades, press tool and pull. Wire is cut and stripped to prop-

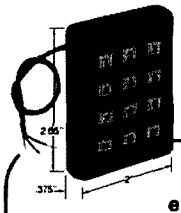
More Details? CHECK—OFF Page 94



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inexpensive bridge rectifiers

Four new low-cost, single-phase, rectifier bridge assemblies — the MDA2550/1 and the MDA3550/1 — have been introduced by Motorola. These economy 25- and 35-amp bridges use prime button rectifiers from Motorola's high-volume, low-cost automotive alternator rectifier line.

The new devices are offered in the most popular 50- and 100-volt ratings. These bridges have 400-amp surge capability and an electrically isolated base up to 1800 volts. Immediate availability is from OEM and authorized Motorola distributor stocks (or contact Motorola Semiconductor Products, Inc., P.O. Box 20912, Phoenix, Arizona 85036).

Mini-Reader

Only a few years ago, to receive in the RTTY mode, you had to spend hours putting together a demodulator, learning how to operate a Model 15 or 19 machine, reloading paper, and on and on. Seemed like you felt more like an auto mechanic than a Radio Amateur. Big and bulky was the name of the game.

Things have changed. The great strides of the electronics industry to miniaturize components have resulted in smaller and smaller products. A good example is the Kantronics Field Day Code and RTTY Reader. The

Tell 'em you saw it in HAM RADIO!

Field Day Reader is large — about the size of an fm transceiver. Kantronics engineers then miniaturized the Field Day to hand size and renamed it the Mini-Reader. The Mini-Reader can do everything that its larger brother, the Field Day; can but in a much smaller package, measuring only 5.75 × 3.62 × 1.25 inches (14.6 × 9.2 × 3.2 cm). The Mini-Reader fits easily into your pocket and comes at the attractive price of $314.95.

Mini-Reader features

The Mini-Reader copies Morse from 3-80 WPM; RTTY with any shift at 60, 67, 75, and 100 WPM Baudot; and 110 and 300 WPM ASCII.

To assist in logging, the Mini-Reader can function as a 24-hour clock. And if that isn't enough, the Mini-Reader can also be programmed to function as an audio-frequency counter. For tuning ease, the Mini-Reader has a tuning LED that indicates exactly when a station is properly tuned in. Also, the Mini-Reader has a built-in 250-Hz bandwidth filter to reduce interference. The earlier Field-Day Reader used digital circuitry, which required a fairly large package. To accomplish miniaturization, Kantronics has designed the Mini-Reader around a programmed microprocessor.

interfacing with your receiver

Hookup of the Mini-Reader is carefully explained in the owner's manual and takes only a few minutes. While connecting the Mini-Reader to a receiver in preparation for this review, we inadvertently put plus to minus and minus to plus. With some equipment this would mean sure disaster or irrevocable damage. But the Mini-Reader, thanks to careful design, took our abuse in stride and worked perfectly when we realized our mistake and corrected the power leads.

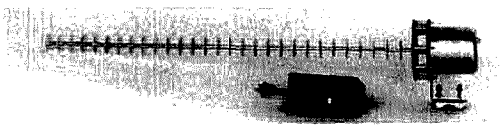
The real test came when audio from the receiver was applied. Tuning across the top of 20 meters, we found a nice strong RTTY signal that was

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Prices including UPS shipment are as follows:

Model RP receiver package **$150**
Model RP + receiver package **$170**
Model RPC receiver package **$170**

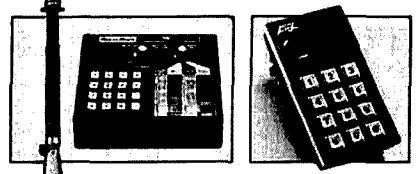
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Output Current	8 amps	3 amps	4 amps	3 amps
Load Regulation	15 volts	1 volts	1 volts	5 volts
Line Regulation	15 volts	1 volts	1 volts	5 volts
Ripple Max. RMS	01V	005V	005V	02V
Current Protection	8A limit	05-3A lim	4A limit	3A lim
Short Protection	1A Foldback	05-3A lim	½A Foldback	3A limit
Crowbar Protection	yes	none	none	none
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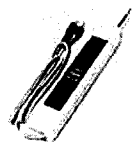
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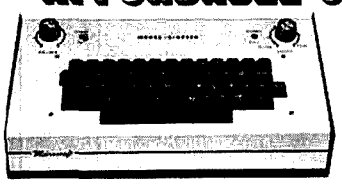
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relatively free from interference. Plugging in the audio jack brought garbled words across the bright green ten digit screen. A small turn of the VFO lit the tuning LED to a bright red and, Hey! This really works — 100 percent perfect copy. We spent at least two hours tuning across the ham bands listening to RTTY transmissions that first night. We also tuned across commercial circuits and had a lot of fun listening to UPI, AP and ships at sea.

receiving manual CW

Enough about RTTY. Now it's time to try the Mini-Reader on CW. As the instruction manual states, decoding CW is not an easy task. This is because of the different techniques and styles of sending Morse code. If everyone's spacing and character weight were the same, code readers wouldn't have any problems.

Despite a bit of skepticism on our part, the Mini-Reader copied every signal we listened to except a ham who was using a bug and seemed to delight in his Lake Erie swing.

The Mini-Reader had a field day with the speed merchants on the low end of the 40-meter band. The only time the Mini-Reader failed to decode signals was in the presence of loud static crashes and QRM.

specifications

Morse speed tracking: 3-80 WPM

Filtering: active 250-Hz bandwidths; 750-Hz center frequency

Display: 10 alphanumeric, 14-segment units

Modes: Morse; Morse with speed display. Morse practice RTTY at 60, 67, 75, 100 WPM, ASCII at 110 and 300 WPM. Clock test and audio-frequency counter.

Audio-frequency counter: 0-79 kHz +0.01 percent

Power: 8-18 Vdc at 240 mA.

The Mini-Reader is a fascinating addition to any Amateur station. For more information contact Kantronics, 1202 E. 23 Street, Lawrence, Kansas 66044. — *ham radio* staff.

HAM CALENDAR

October

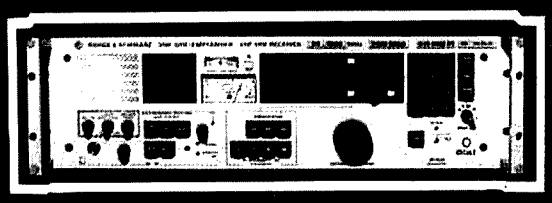
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				WEST COAST QUALIFYING RUN – 1. **1**	**TEXAS STATE CONVENTION** – K5RC, 12610 Barbizon, Houston, TX 77088. 2-4. **2**	**RADIO AMATEURS OF GREATER SYRACUSE HAMFEST** – Art & Home Bldg., NY State Fairgrounds. WA1DA or KN2CZZ. 3. **SUNCOAST CONVENTION** – Sheraton Sand Key Hotel on Sand Key, South of Clearwater Beach. W4EGM. 3-4. **MIDWEST DIVISION** – Salina, KS. John Shoutys, 2157 Edward, Salina, KS 67401. 3-4. **MISSISSIPPI COAST ARA** – Biloxi, MS. W5PDG. 3-4. **CALIFORNIA QSO PARTY** – 3-4. **VK/ZL PHONE CONTEST** – 3-4 **3**
19-76 REPEATER ASSOCIATION'S ANNUAL FLEA MARKET – Beachmont VFW Post, 150 Bennington St., Revere, MA. K1AZE. 4. **GIANT ELECTRONICS FLEA MARKET** – Loral Electronics Parking Lot, Fullerton Ave., Yonkers, NY. Call (914) 969-1053. 4. **YORK COUNTY 30TH ANNUAL HAMFEST** – Joslin Park, Rock Hill, SC. WA4QQG. 4. **4**	**BLOSSOMLAND ARA 15TH ANNUAL HAMBASH** – Lake Michigan College Convention Center, near Benton Harbor, MI. WB8WIV. 5. **5**	**6**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **7**	**8**	**SCOTTSDALE ARC SOUTH WESTERN DIVISION CONVENTION** – Safari Resort, Scottsdale, AZ. 9-11 **WORLD'S FAIR OF ELECTRONICS** – The Electronic Emporium, Ross at Central, Dallas, TX. 9-10. **9**	**WESTERN NORTH CAROLINA ARS 1981 AUTUMNFEST** – Asheville Civic Center, Asheville, NC. 10. **VK/ZL CW CONTEST** – Contact VK6NE for details. 10-11. **DELTA DIVISION CONVENTION** – Memphis, TN. 10-11. **9-LAND QSO PARTY** – Contact WB9IWN for details. 10-11. **10**
HOOSIER HILLS HAM CLUB ANNUAL HAMFEST – Lawrence Co. 4-H Fairgrounds, South of Bedford, IN WA9OOT. 11. **COLUMBIA ARA FIFTH ANNUAL HAMFEST** – Howard County Fairgrounds, 15 miles west of Baltimore just off I-70 on Rt. 144. N3AFN. 11. **RSQB 21/28 MHz PHONE** – 11. **11**	**12**	**W1AW QUALIFYING RUN** – 13. **13**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **14**	**15**	**16**	**FIRST ANNUAL BIG RAPIDS FOX HUNT** – Transmit Freq. 146.64, Hemlock Park, Big Rapids, MI. Contact B.R.A.A.R.C., P.O. Box 1073, Big Rapids, MI 49307. 17. **ORP ARC INTERNATIONAL CW QSO PARTY** – Starts 1200 UTC Sat., Oct. 17, ends 2400 UTC Sun., Oct. 18. For more information contact WA2JOC. 17-18. **24TH JAMBOREE ON THE AIR** – 001 UTC Saturday to 2400 UTC Sunday. Contact Boy Scouts of America, 1325 Walnut Hill Lane, Irving, TX or Harry A. Hatcher, 216 Maxwell Ave., Hightstown, NJ 08520. 17-18. **27TH ANNUAL VHF CONFERENCE** – Western Michigan University, Kalamazoo, MI 49008. For more information contact: (S.A.S.E.) W9UHF. 17. **17**
PENNSYLVANIA QSO PARTY – Contact 3HOH. 17-18. **RSQB 21-MHz CW CONTEST** – 18. **18**	**19**	**20**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **21**	**22**	**23**	**HAMFEST CHATANOOGA** – Chatanooga State Technical College, Chatanooga TN. Contact WA4ZOK. 24-25. **24**
FRAMINGHAM ARA 8TH ANNUAL FALL FLEA MARKET – Framingham Police Station Drill Shed. Contact K1YHM for more details. 25. **W1AW QUALIFYING RUN** – 25. **25**	**26**	**27**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **28**	**29**	**30**	
						W1AW Schedule **April 26-October 25, 1981** UTC Slow Code Practice: MWF: 0200, 1300, 2300; TThSSn: 2000; S: 0200 Fast Code Practice: MWF: 2000; TTh: 0200, 1300; TThSSn: 2300; S: 0200 CW Bulletins: Dy: 0000, 0300, 2100; MTWThF: 1400 Code practice and CW bulletin frequencies: 1.835, 3.58, 7.08, 14.08, 21.08, 28.08, 50.08, 147.555 MHz. For more details see Coming Events

NOVEMBER 1981
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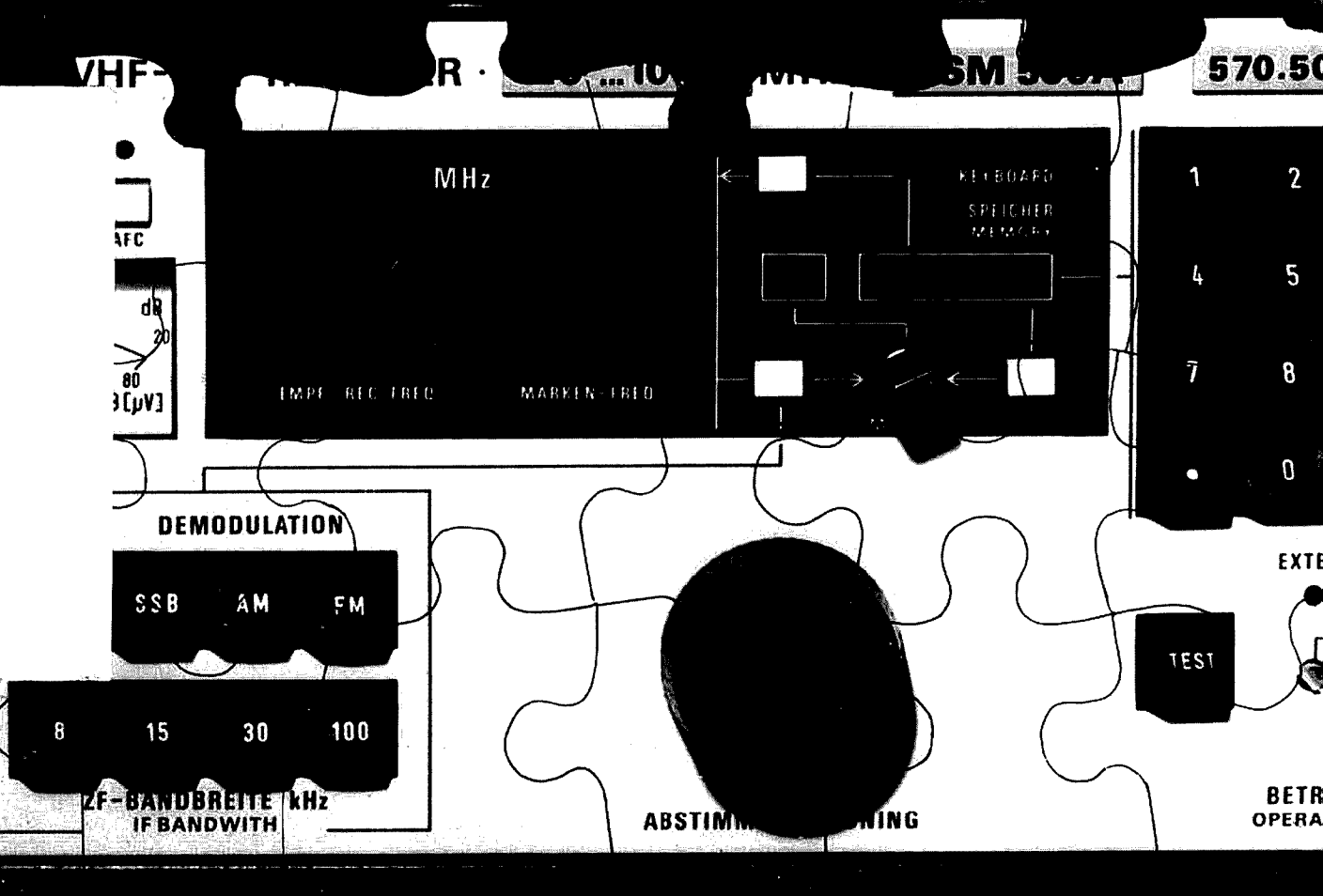
incorporating
HAM RADIO HORIZONS

ham radio magazine



designer's challenge:

RECEIVER OF THE FUTURE



ham radio magazine

incorporating HAM RADIO HORIZONS

NOVEMBER 1981

volume 14, number 11

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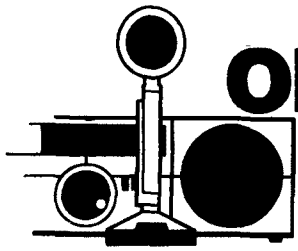
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Observation & Opinion

Now is your chance to make a real contribution to Amateur Radio. The FCC has authorized the operation of an experimental beacon on the new WARC bands of 10.100-10.150, 18.068-18.168 and 24.890-24.990 MHz. As you read this, the beacon will have been in operation about a month, and quantitative information is needed regarding the reception of signals.

The experiment is intended to permit Amateurs to become familiar with the characteristics of these bands, which will help to simplify the scheduled future change-over to full Amateur use. The experiment will improve Amateur use of these new parts of the spectrum and will provide data on sharing between different services. An important element is obtaining data on propagation under weak-signal conditions, typical of natural disaster situations. It should be remembered that this use is one of the major reasons for these new authorizations, the first in many years.

The experiments will include two types of emission, three operating modes and two time phases. Basic emission is unmodulated carrier (AØ), which will be interrupted each ten minutes for an SSB (2.8A3J) identification and announcement. The voice announcement will occur at 2, 12, 22 . . . minutes past the hour. The announcement will be of the form, "This is FCC-authorized experimental station KK2XJM, Daytona Beach, Florida. QSL via W4MB. Next operation will be repeated on _____ MHz starting on _____," and will be repeated. The announcement will be made by a woman, as the timbre of the female voice makes speech easier to recognize under unfavorable conditions.

Initial operations will commence about the first of October, using 3 watts ERP on the 10-MHz band. Depending on results, the operating schedule will include the 18- and 24-MHz bands. Later phases will include operation at 30 watts ERP, with sequencing from band to band, sometimes weekly and sometimes daily, as needed to make optimum use of the bands for propagation experiments both worldwide and to specific areas.

The licensee for the experiment is Bob Haviland, W4MB. Bob is well qualified for this important task. He has been an Amateur for 50 years and has participated in numerous CCIR and ITU conferences and preparatory work. He was chairman of the 28-1215-MHz allocation subcommittee of the FCC's WARC Advisory Committee for Amateur Radio, project engineer of the program that placed the first radio transmitter beyond the ionosphere, and has worked extensively on communications and broadcast satellites. Bob published the first known proposal for an Amateur Radio experiment on a satellite. Additionally, he has been on a number of DXpeditions, having operated from four continents. And, not incidentally, Bob has been a prolific contributor to *ham radio*, having published some nine articles over the years.

The success of the experiment will depend on participation by Amateurs and shortwave listeners, and on their reports. Information needed is the date, time and location of reception, strength of the beacon signal and other signals on the band, and the type of receiving installation including, of course, the antenna. All reports will be acknowledged by a QSL card.

In addition to reception reports, proposals for special tests will be welcomed, subject to the limitations imposed by the license and by regulations for experimental stations. KK2XJM is not authorized to communicate with Amateur stations; however, reports, requests for schedules and proposals for experiments may be sent to W4MB's *Callbook* address.

This venture is a fine opportunity for everyone to contribute to the advancement of Amateur Radio. A QSL card from W4MB acknowledging participation in the experiment certainly should become a valuable reminder of an important phase of Amateur-Radio development.

Alf Wilson, W6NIF
editor



comments

work the Pacific

Dear HR:

I would like to inform your readers of the basic Work The Pacific award, which is issued for thirty confirmed contacts on the WTP country list. It's available to any licensed Amateur Radio operator and to SWLs.

Mode, band, power level, and other endorsements will be made upon request with the original application only. The award is printed in four colors on a beautiful parchtone bond.

For more information, please contact me at the address below.

Award Manager, C.H.C.
Scott R. Douglas, Jr., KB7SB
P.O. Box 46032
Los Angeles, California 90046

zero beat

Dear HR:

The July, 1981, issue of *ham radio* arrived today. Naturally, the point of first reading was the "Observation and Opinion" page relative to transceivers and zero beating. Oddly, the timing was in itself a true zero beat for a project completed several weeks ago on a unique (and modified) circuit by Jerry Assard, KA1EVW, which appeared in the March, 1979, issue of *Electronic Design News*, entitled "Lamps Monitor Beat Frequency."

I built the device with modifications stemming directly from my totally home-brewed rig, which demanded some strange and totally unique approaches both to transceive and shift-band transmissions that many of the rare DXers employ.

The basic capability of the Assard system may well be adapted to any number of other uses related to and stemming from the article. I will be happy to supply the complete circuitry (with full credit to Jerry Assard for his original and fine thinking) to any ham interested in applying this useful tool. Please send a self-addressed, stamped envelope to P.O. Box 6175.

Gene Shapiro, WØDLQ
Leawood, Kansas 66206

more free inductors

Dear HR:

In my recent CW filter articles (*QST*, December, 1980, and *ham radio*, April, 1981), I stated that I was serving as liaison between the Chesapeake and Potomac Telephone Company of Maryland and the Amateur fraternity, assisting in the distribution of surplus telephone line 88-mH loading coils. These inductors are being given to Radio Amateurs free (except for my shipping expenses) as a public service by the C & P Telephone Company.

I've processed more than fifty requests for inductors so far, but now the initial response to these two articles is quieting down. I would appreciate it if you would mention in your magazine that I still have inductors (88-mH inductors in a five-inductor stack form). They are available to anyone interested in applying them to Amateur Radio filtering applications. Write to me at my *Callbook* address explaining your need and proposed application. A stamped, self-addressed envelope must be included for my reply with further instructions.

Ed Wetherhold, W3NQN
Annapolis, Maryland

antenna restrictions

Dear HR:

Most people worry only about the zoning ordinances and building permits that may be needed for the installation of ham antenna systems. But it's necessary to check your deed and the title to your land to see whether there are any protective covenants that prohibit the placing of any tower, pole, or similar structure on your own property. These restrictions will also appear in the title search of your property when you buy a home.

You may not be aware that you waived your rights (or you may not have been aware of your rights) when you made settlement on your house and land, legally binding yourself to these protective covenants. These covenants were originally designed to protect all the homeowners in your housing development for esthetic reasons, to enhance the neighborhood's appearance and to keep property values from declining. These covenants may be part of the land and deed for as long as 10 to 25 years, and, at that time, they may be automatically renewed for another 10 to 25 years unless changed by the members of your housing development. Violation of any one or more of these covenants could result in litigation against you by a neighbor or neighbors, and much time and money spent in the courtroom.

These covenants are another blow against the ham radio operator, who may not even be able to use his own land for the installation of his dream antenna farm. It appears that more and more single-home housing developments, townhouses, twin homes, duplexes, condominiums, and apartments are placing more and more antenna restrictions on their buildings for esthetic reasons, and in turn these restrictions are slowly taking away your rights.

Take it from one who has been that route and knows from first-hand experience. Check the agreement of sale and deed before you sign on that dotted line. Don't spend hundreds, or thousands, of dollars in the courtroom, or be forced by a judicial court order to dismantle your antenna system.

Robert N. Wilderman, K3SRO
Lansdale, Pennsylvania

presstop

THE ARRL DIRECTORS CONSIDERED organizational changes proposed by the Long Range Planning Committee, the Central Division Recall, changes in subbands and bandplans, a new ARRL periodical, its Washington representation, and a host of other topics when it met in Newington September 9-10.

The Long Range Planning Committee proposed an extensive reorganization of the League at the state and local level, with a newly created post of Section Manager for each of the 73 sections, creation of division steering committees, and redesign of the Advisory Committees with a representative from each division serving on each AC. This program was endorsed by the board, which asked for specific plans, cost information, and implementation timetables for consideration at the next board meeting.

The Central Division Recall and Bylaw 20 were both considered at length, but no action was taken on various proposed changes in the recall bylaw because of the pending recall vote. However, the board did vote to permit Director Metzger to include a statement in his own behalf with the recall ballot (along with statements by the ARRL and the Indiana Radio Club Council), an addition that was agreed to by the Executive Committee.

The Proposed 160 Meter Bandplan (August QST) was adopted unanimously based on the very favorable response to the article in QST, but the previously passed motion to expand 40-meter Extra phone privileges was withdrawn. The board also voted unanimously to petition the FCC to expand General-class phone on 75 down to 3860, and to permit the "automatic control" of beacons. It also adopted 20-kHz channel spacing for the 144.5-145.5 repeater subband, and requested completion of bandplans for both 6 meters and 23 cm in time for the 1982 annual meeting of the board.

A New Beginner/Novice Periodical may be in the offing. The General Manager, Membership Affairs Committee, and Plans and Programs Committee were directed to study the feasibility of such a publication with a report due at the first 1982 board meeting. The board also voted to establish a separate ARRL publications price list for members buying them from Headquarters, to go into effect no later than January, 1983.

Improved Washington Liaison efforts, the tightening of the regulations for single-mode DXCC awards, the extension of all current Advisory Committee appointments pending further consideration of the Long Range Planning Committee's recommendations on AC makeup, and even a review of the usefulness of the "T" in RST CW reports were also voted on in this far ranging session.

OBSCENE LANGUAGE ON THE AIR should no longer be an FCC problem, the Commissioners voted September 17 in a wide-ranging recommendation to Congress for changes in the Communications Act. Although most of the Commissioners' proposals dealt with the regulation of broadcasting, proposals pertaining to the question of obscenity will affect the Amateur service (and other services) as well.

The Commissioners Voted unanimously to drop their right to revoke a station license for violation of obscenity statutes, and voted 4 to 2 in favor of amending Section 326 to strip the Commission of "any power of censorship over the content of communications." With obscene or other objectionable language no longer a concern of the Commission, any prosecution of foul-mouthed Amateurs would then go to the Justice Department.

A NEW RFI SOURCE is beginning to cause problems to Amateurs, particularly in rural areas. The troublesome device is the CMH, a multiplexer that provides eight multiplexed voice channels over a conventional phone line. The problem is in its switching-type power supply, which operates at 79 kHz and generates harmonics well into the VHF spectrum. These harmonics are radiated through the phone lines it is tied into.

CMH-Generated Interference shows up on the bands as slightly unstable signals that appear every 79 kHz.

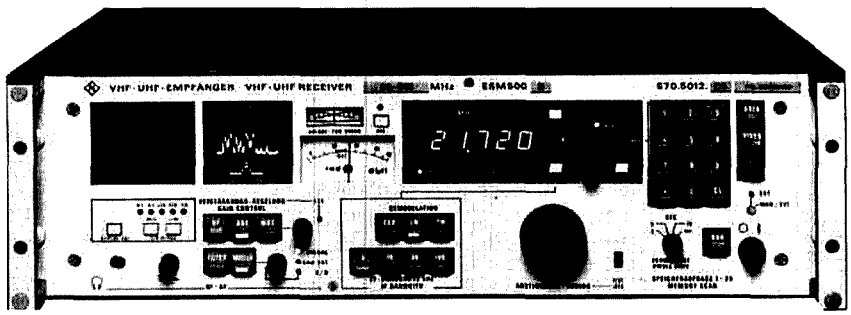
THE "PLAIN LANGUAGE" AMATEUR RULES rewrite may be turning out to be a dead issue. In a letter to a Lincoln, Nebraska, Novice (KAØJYZ), Senator Barry Goldwater, K7UGA, stated that, "The rules changes in language have been stopped for the time being, and I think when we get better acquainted with the new head of the FCC we can forget all about them."

With The ARRL And Many Individual Amateurs lukewarm or even opposed to the rewrite as it is now proposed, the Goldwater opposition may very well be the signal of the demise of the rewritten Amateur rules.

BOB STANKUS (KESWICK SALES) pleaded not guilty to 22 counts of mail fraud at his first appearance before the judge on July 6. After some discussion between the lawyers, however, he decided to change his plea to guilty on 11 of the 22 counts in return for having the other 11 charges dropped. The court is now awaiting a probation report on Stankus, and after the report is received he will be sentenced for his part in the "bargain" TS-520S mail-order sale scheme.

1981 WINNERS OF THE EIGHT SCHOLARSHIPS that were administered by the Foundation for Amateur Radio are KAØDGT, WB7RVP, WA1WFA, WA2CUN, KA7BWC, KA5BOU, and KA2DYC. Congratulations to all.

communications receivers



for the year 2000

Part 1: New designs, microprocessors, input filters, and mixers

Some changes have occurred since my paper[1] appeared on optimum design for high-frequency communications receivers:

1. The sunspot cycle has given better propagation conditions.

2. Manually operated receivers have become "intelligent" with the advent of built-in microprocessors.

3. Receiver dynamic range has been increased with better amplifiers and mixers.

4. Blocking problems have diminished with better synthesizers.

5. Better dynamic performance of filters has improved reception on crowded frequencies (note that *dynamic* selectivity is not the same as *static* selectivity, which is discussed later).

6. Frequency resolution and acquisition have increased dramatically.

7. Up conversion avoids gaps in frequency coverage. Many new receiver designs use an LO and intermediate frequency higher than the highest frequency of reception.

8. Lowpass filters in the receiver front end, combined with suboctave filters, tunable circuits, or both, obtain constant image and i-f suppression. Such design guarantees image-response suppression and substantially reduces LO re-radiation.

9. As the output oscillator in a synthesizer has a range of less than 2:1, design of these oscillators has become simpler.

In retrospect I find that my earlier predictions have been substantially correct and that advances in technology, specifically in digital techniques and microprocessor design, have been much faster than in rf-circuit design.

What can we expect in the future? Let's look at today's communications-receiver technology in terms of the year 2000.

receiver specifications

Communications receivers are best described by their specifications. Table 1 shows data for a communications receiver covering 10 kHz-30 MHz, and table 2 shows specifications for a communications receiver covering 20 MHz-1000 MHz. These are clearly general-coverage receivers, and one may ask, What does this have to do with ham radio?

Most engineers working on Amateur receivers have had experience in commercial design, and while I've always said that the crowded ham bands are a greater challenge to the receiver designer (this holds true only for the shortwave area), general-coverage

By Ulrich L. Rohde, DJ2LR, 52 Hillcrest Drive, Upper Saddle River, New Jersey 07458

receivers monitor *all* frequencies and, therefore, must be able to survive this hostile environment — a real design challenge.

In terms of energy, there is now really more energy available for injection into the antenna of a VHF/UHF receiver than at the input of a VLF/HF receiver; and the dynamic range requirements for VHF/UHF receivers are now even higher because the noise floor is substantially lower than in receivers for the shortwave bands.

new approaches in design

Fig. 1 is a block diagram of a VLF/HF receiver with microprocessor control and other features. It's not very likely that this receiver will be smaller or better designed in coming years.

As we shall see later, dynamic range is determined by a) the mixer and the LO drive (a question of drive power and therefore power consumption), or by b) the dynamic range of the amplifiers (again, it becomes a question of power consumption versus dynamic range).

Let's look at the block diagram. As the receiver must handle extremely large signals at times (to the point where the input circuit can be burned out), an input attenuator is a good protective device.

Modern receivers should have a self-test circuit and, therefore, we find in the block diagram (from the Rohde & Schwarz EK070 receiver) a built-in noise generator that allows one to monitor the signal over the entire receiver.

One of the ten input filters may be automatically selected and determined by the synthesizer. The incoming frequency is up converted to a first i-f of 81.4 MHz, where a crystal filter (12 kHz) narrows the number of frequencies fed to the second mixer. The two mixers use several filters and amplifiers. The output is taken at the second mixer and is available for a panoramic adapter.

As in all modern receivers, independent sideband detection is required. Two complete i-f strips and two filters are included, one for upper and one for lower sideband. For all other modes, only one channel of the i-f is used.

The AGC must be individually determined for each channel. To be able to have passband tuning and to select different combinations of bandwidths and BFO frequencies, the BFO must be synthesized. Note that the synthesizer for the first and second LO, as well as that for the BFO, are fairly complex. This is a result of the requirement for extreme high dynamic range, low-noise sideband performance, fast switching speed, and spectral purity (high reference-signal suppression and no other unwanted frequencies).

In addition to the familiar modulation schemes, there are a number of digital modes such as ASCII, Baudot, and pulse-code modulation (both a-m and fm). (In many cases, these signals are scrambled and are not available for immediate detection.)

A clever scheme allows a 12.5-kHz output that can be connected to a tape recorder — unidentified signals can be recorded and stored for later detection. In addition to these features is a built-in RTTY demodulator, including an indication of center frequency for the RTTY demodulator that eliminates the need of an oscilloscope for tuning.

microprocessors and receivers

We have heard much about microprocessor applications in receivers, and many of us use 2-meter transceivers or other equipment that incorporates microprocessors. What does the microprocessor actually do for us? The microprocessor automatically handles certain routines such as scanning of frequencies written into memory. After the microprocessor has put these frequencies into the receiver's memory, one can determine the field strength from the AGC line, compute this into absolute microvolts, dB above 1 microvolt, or dBm, as required. Also, the microprocessor can control the synthesizer and take care of all the arithmetic. The synthesizer frequency and the frequency on the display of the receiver are not the same; this offset can be taken into consideration by the microprocessor.

The built-in self-check of a shortwave receiver will allow monitoring of certain functions to make sure the receiver is operating properly. This brings up several important questions:

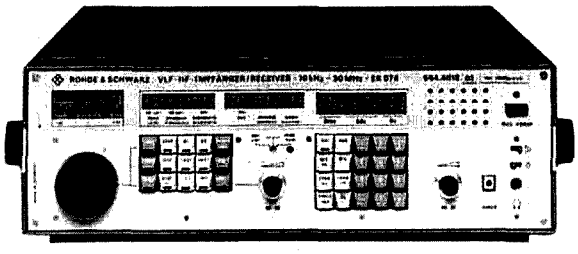
1. Are we not trading flexibility and reliability for automation?

2. Is the microprocessor now such an important part that, once it fails, nothing will work anymore?

3. Can we repair microprocessor-based communications receivers?

There is no question that test instruments required to service microprocessor-based instruments are more expensive and demand more training for repair technicians, and the price for the components of the computer system are not low enough to justify discarding questionable integrated circuits.

I believe that there are still two extremes that will remain for a while at least. The Rohde & Schwarz EK070 receiver (photo), is designed for the future; and, as mentioned earlier, even in the year 2000 we will not be able to make the rf portion much better, insofar as improvements over the last five years have been much less dramatic than those from 1960 through 1975.



The Rohde & Schwarz EK070 receiver.

Another photo shows the Model HF1030 VLF/HF communications receiver (formerly from Communications Products Corporation — now being manufactured and sold by Cubic Communications Corporation). This receiver is in the $6,000 price range, while the Rohde & Schwarz EK070, depending upon the options, costs between $14,000 and $20,000.

Rf characteristics such as intercept point, image suppression, blocking, and switching speed for both receivers are comparable — only housekeeping and utility functions such as memory, built-in RTTY demodulator, and self-check are different. It is therefore the decision of the user how much he wants to spend and what type of receiver he wants.

The frequency range of 20-1000 MHz requires higher dynamic performance and more scanning and searching capabilities. The absolute bandwidth of this frequency range is much wider; and for frequency searching or frequency hopping, more requirements are demanded of the frequency synthesizer. The fm capability requires more bandwidth choices. A typical example is the Rohde & Schwarz ESM500 receiver. Its performance characteristics are listed in table 2.

We have heard so much about increased performance capability that we will want to look at several circuits and see how these improvements are achieved. But, one note of caution: microprocessors have become a national obsession, and a device not having a built-in microprocessor is not considered modern — a misleading notion! The microprocessor is nothing more than a device that can execute instructions sequentially and at fast speed.

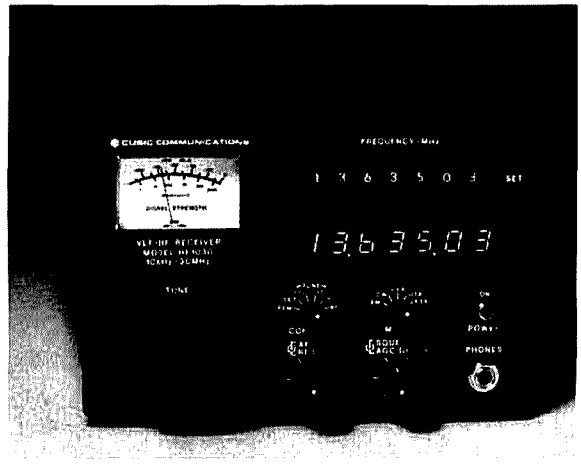
Standard circuits with normal gate decoding do everything in parallel; for practical purposes there is no execution delay. As the microprocessor becomes overloaded speed and flexibility are lost. To write extremely long programs for microprocessors in assembly language requires substantial knowledge in programming and debugging. As a result, the present tendency is to break up the tasks by using a central microprocessor; for reasons of speed, a 16-bit unit such as the Motorola 68000 is used, as well as several independent processors in slave mode — the most popular are the 8085 or, for smaller tasks, the 8748 or 8749.

The microprocessor is not always a necessity, and the tradeoff between cost and speed introduces another hazard. Every microprocessor requires an internal clock. Sometimes these clocks are at frequencies that cannot be generated from the master standard and, therefore, additional frequencies occur, generating radio interference and spikes inside the receiver. It becomes a major task to shield and insulate one or more microprocessors and their switching noise from the outside.

The HF1030 receiver is a good example where flexibility is obtained by a parallel BCD bus that controls the entire receiver and does not require a microprocessor. Even the LED display is not multiplexed. A receiver that can go down to 10 kHz will probably pick up this switching noise, then the additional shielding required can be more expensive than the reduction in cost by using a microprocessor over conventional logic. Some companies offer programmable logic-array ICs, which would take an intermediate position between the logic and the microprocessor system.

input filters

Current receiver designs generally use a highpass/lowpass filter combination. Typically, a 1.6-MHz highpass is used to suppress incoming signals, and a 30-MHz lowpass filter is used to provide image rejection and prevent oscillator re-radiation. We therefore have a window almost 30 MHz wide that can lead to several second-order intermodulation distortion products.



Cubic Communications HF1030 receiver.

table 1. Specifications of a modern VLF/HF receiver.

frequency range	10 kHz to 30 MHz
frequency setting	a. quasi-continuously by rotary switch in increments of 10 Hz/100 Hz/1 kHz b. digital entry via keyboard c. remote control via data interface (setting time 50 ms)
readout	7-digit liquid crystal display
resolution	10 Hz
frequency drift	
after 10 minute warmup	$< 3 \times 10^{-7}$ at +25°C
within one day	$< 3 \times 10^{-8}$
caused by aging	$< 1 \times 10^{-6}$/year
in rated temperature range	$< 3 \times 10^{-7}$
types of emission	A1 (CW, A2 (MCW), A3 (a-m) A2H, A3H (AME) } (SSB) upper A2A, A3A } and lower A2J, A3J } sideband A3B, (ISB), F1 (FSK)
with telegraphy demodulator	F4 (facsimile) F6
antenna input	Z_{in} = 50 ohms, BNC female connector
VSWR	< 3
permissible input voltage	≤ 10 V EMF
oscillator reradiation	< 10μV at antenna input with 50-ohm termination
sensitivity*	for 10 dB (S + N)/N, 0.2 = 30 MHz
with A1, B = 300 Hz	< 3μV EMF
with A3, B = 6 kHz, m = 60%	< 2.0μV EMF
with A3J, B = 3.1 kHz	< 0.75μV EMF
preselection	0 to 0.5 MHz; lowpass filter 0.5 to 1.5 MHz; bandpass filter — 8 suboctave filters between 1.5 and 30 MHz
intermediate frequencies	
1st i-f	81.4 MHz, B = 12 kHz
2nd i-f	1.4 MHz
i-f selectivity	3dB bandwidth (minimum) / 60 dB bandwidth (maximum) ± 75 Hz / ± 225 Hz ± 150 Hz / ± 375 Hz ± 300 Hz / ± 750 Hz ± 750 Hz / ± 1875 Hz ± 1.5 kHz / ± 3.75 kHz ± 3 kHz / ± 7.5 kHz ± 6 kHz / ± 50 kHz +0.3 to +3.4 kHz / −0.3 to +4.0 kHz −0.3 to −3.4 kHz / +0.3 to −4.0 kHz
interference immunity, nonlinearities	
intermodulation*	
d_3 within A3J sideband	> 46 dB down, wanted signals 2 × 10 mV EMF
d_3, Δf ≥ 30 kHz	> 70 dB down, unwanted signals 2 × 100 mV EMF
d_2 (1.5 to 30 MHz), Δf ≥ 30 MHz	> 70 dB down, unwanted signals 2 × 100 mV EMF
blocking*	< 3 dB signal attenuation, wanted signal 1 mV EMF, m = 30%/1 kHz; unwanted signal 1 mV EMF, Δf ≥ 30 kHz

table 1. Specifications of a modern VLF/HF receiver (cont.)

cross-modulation*	<10% modulation transfer; unwanted signal 200 mV EMF, m = 30%/1 kHz; wanted signal 1 mV EMF, Δf ≥ 20 kHz
desensitization*	20 dB SINAD; wanted signal 30 μV EMF, B = 3.1 kHz; unwanted signal 300 mV EMF, Δf ≥ 30 kHz
inherent spurious signals	<0.5 μV equivalent EMF
spurious responses	>90 dB down at Δf ≥ 30 kHz
image frequency rejection	>80 dB
i-f rejection	>90 dB
rf gain control, switchable	MGC MGC + AGC AGC
control range	>100 dB
AGC error	<4 dB (1μV to 100 mV EMF)*
attack time	5 ms (level jump + 60 dB)
decay time (switchable)	0.4 s/1.8 s (level jump − 60 dB)
BFO	variable in 100-Hz steps over ±3.1 kHz
attenuation at i-f output	>50 dB referred to i-f level
F1 demodulator	
limiting factor	>40 dB
line spacing	50 to 1000 Hz
keying speed	1 to 100 bauds
signal distortion	<5% at 100 bauds
single current	40 to 60 mA, variable; EMF = 60V
double current	in compliance with CCITT V.28
outputs	
1st oscillator 81.4 to 111.4 MHz	0 dBm, 50 ohms
2nd oscillator 80 MHz	0 dBm, 50 ohms
1-MHz output	50 mV into 50 ohms
switchable to 1-MHz external reference input	30 to 500 mV into 50 ohms
2nd i-f 1.4 MHz	50 mV into 50 ohms
recording output 12.5 kHz	0 dBm, 600 ohms
panoramic output 1.4 MHz	B = 12 kHz
af line outputs 600 ohms	floating
output level	−10 to +3 dBm, adjustable
distortion	<1% with A3J
af output 5 ohms (headphones output 100 ohms)	
output level	1 W (12 mW, can be attenuated)
distortion	<5%
signal characteristics	
af response (overall)	<3 dB from 300 to 3400 Hz
af S/N ratio	>40 dB SINAD with 1 mV EMF
phase noise ratio with A3J	>75 dB with >300 Hz spacing and 1 Hz measuring bandwidth, 1 mV signal EMF
remote control	interface in compliance with IEC and CCITT
IEC bus	IEC 625-1, 24-way connector (Amphenol); functions: T5, L3, SR1, RL2
or (depending on order number)	
RS232C	CCITT V.24, switchable to CCITT V.10 (RS 423) 110/200/300/600/1200/2400/4800/9600 bauds
code	ASCII 7 bits

*without 20-dB attenuator pad

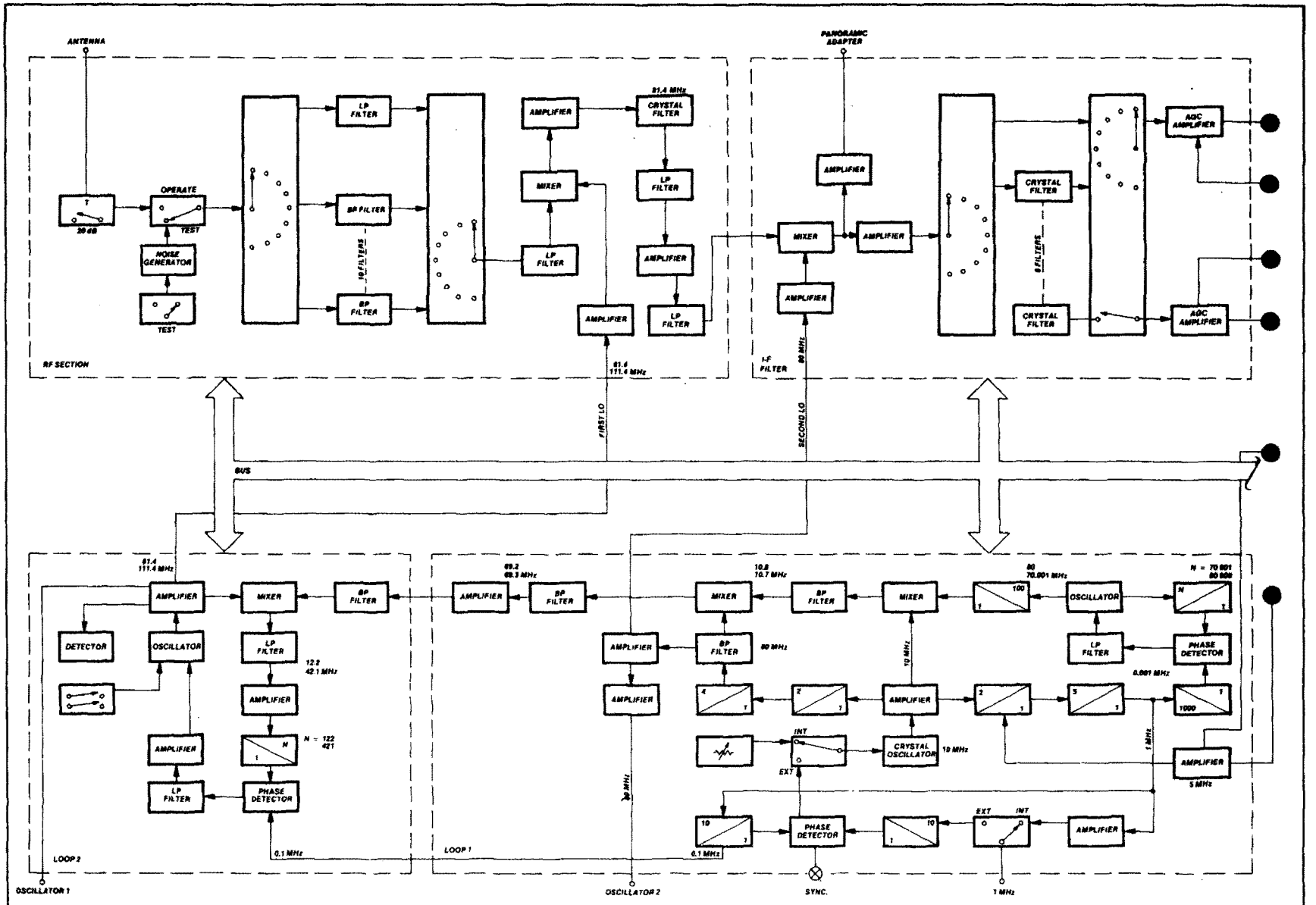


fig. 1. Block diagram of the Rohde & Schwarz EK-070 VLF/HF receiver.

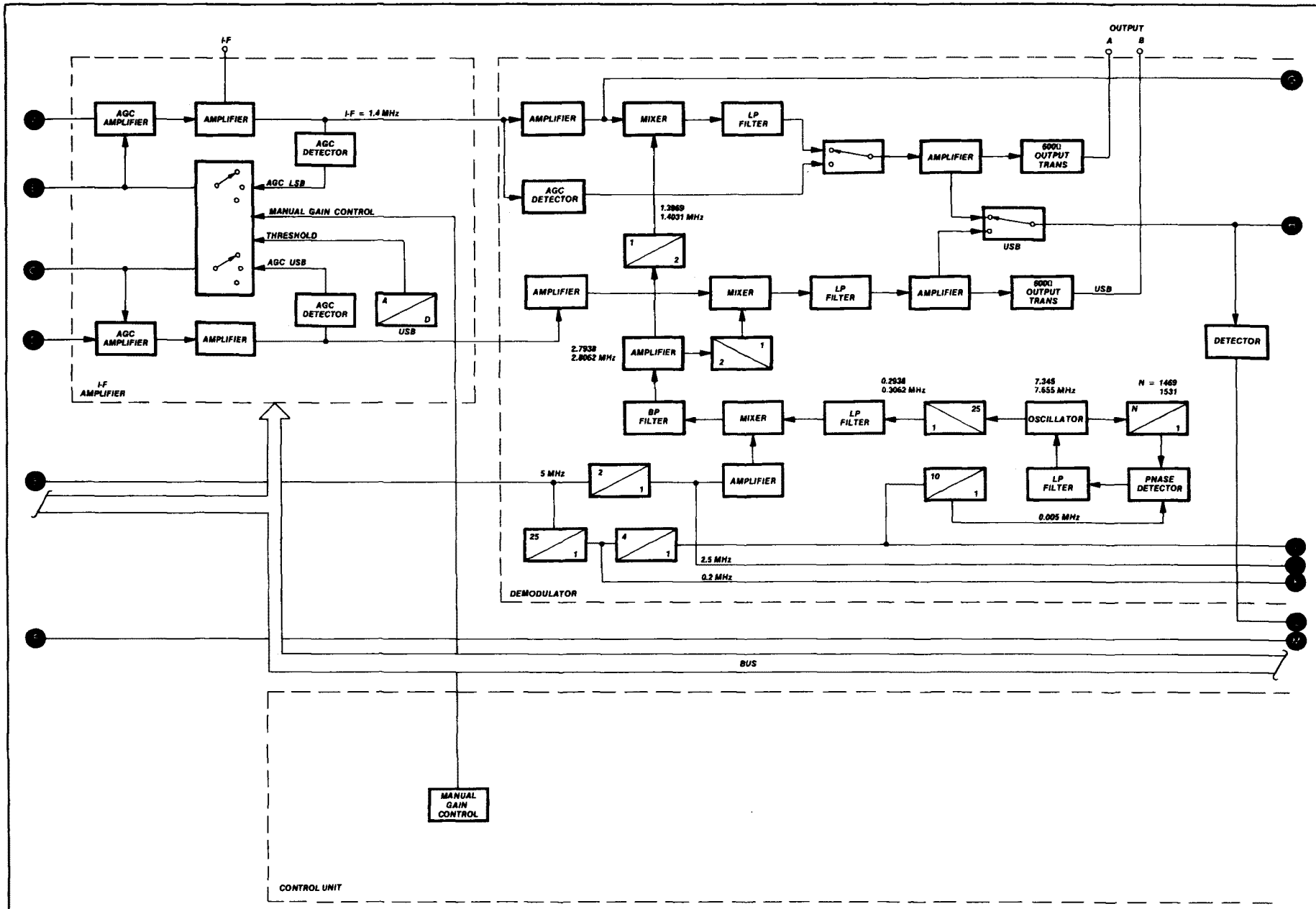


fig. 1-2. Block diagram of the Rohde & Schwarz EK070 VLF/HF receiver (continued).

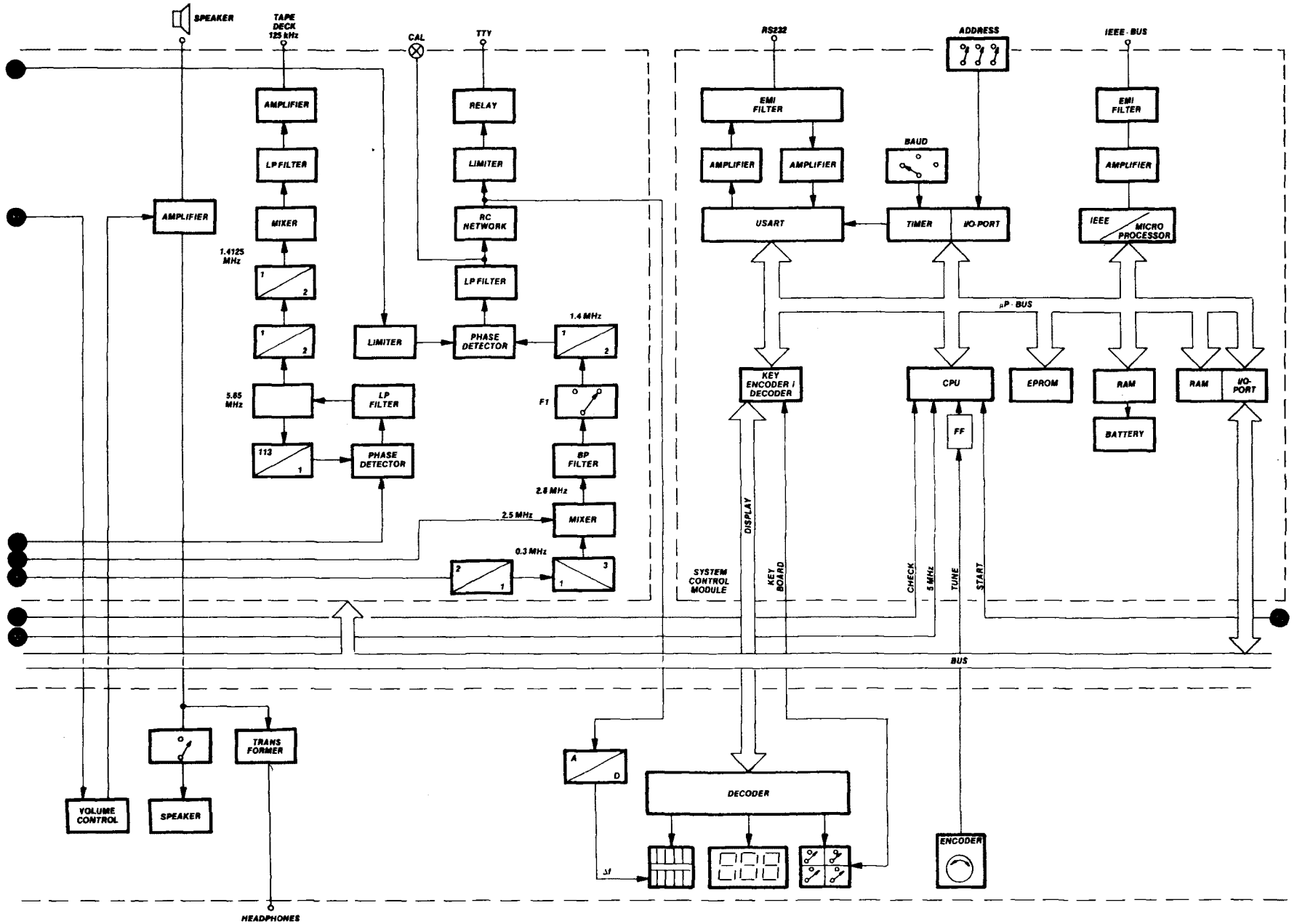


fig. 1-3. Block diagram of the Rohde & Schwarz EK070 VLF/HF receiver (continued).

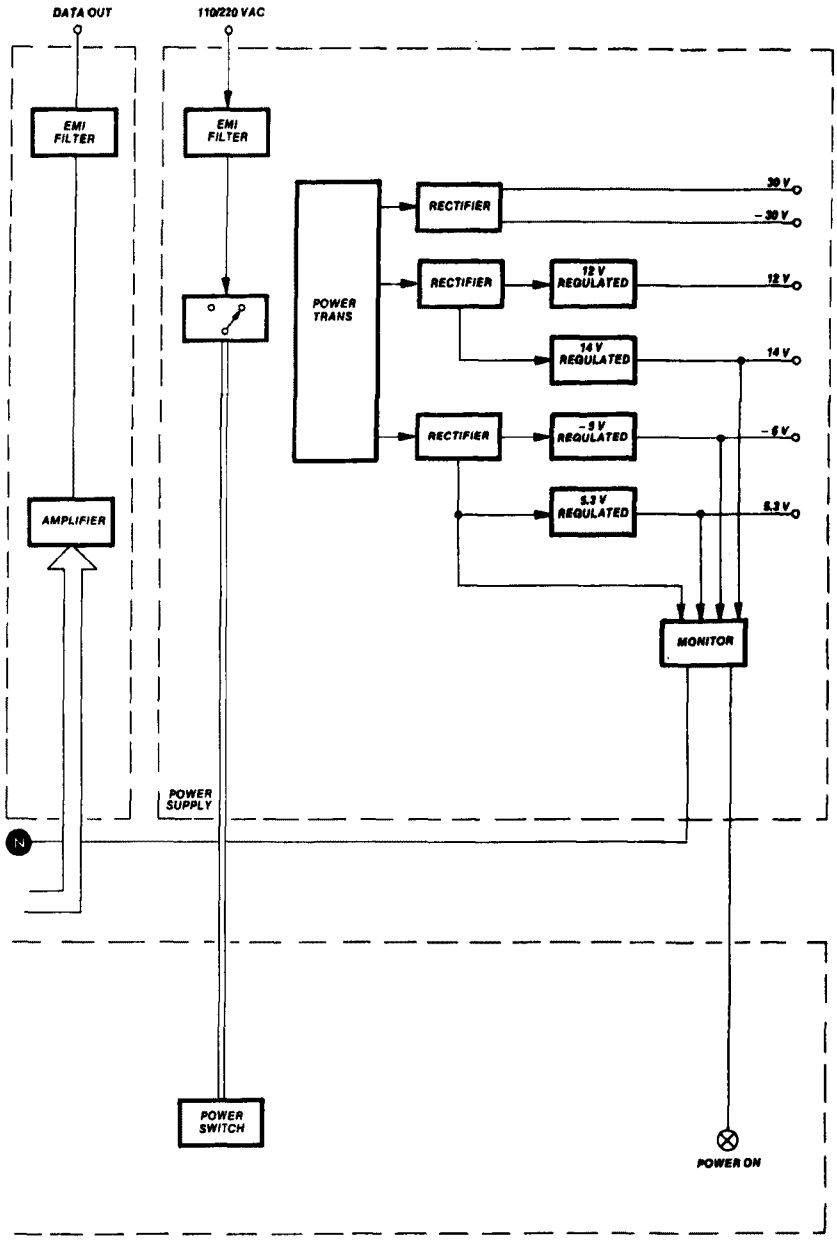


fig. 1-4. Block diagram of the Rohde & Schwarz EK070 VLF/HF receiver (continued).

The second-order intermodulation distortion, defined as $F_1 \pm F_2$ or $F_2 \pm F_1$, can be filtered with suboctave bandpass filters. The third-order intermodulation distortion products generated from $2 \times F_1 \pm F_2$ and/or $2 \times F_2 \pm F_1$ for close spacing, such as 10 kHz or closer, cannot be filtered. However, since there are so many signals present at the same time, the input bandwidth should be as narrow as possible.

Fig. 2 shows a solution that combines bandpass filters from 1.5-10 MHz and two input tracking filters from 10-30 MHz. Note the large number of tuning diodes in parallel. This is because no diodes are available that have the required high capacitance. In addition, intermodulation distortion products are reduced if the energy is distributed over more capacitance. Four-to-one stepdown transformers are used.

Because the tuned circuit operates at low impedance, both sides of the tuned circuit operate at 50 ohms. This input filter, despite the tuning diodes, does not degrade the 30-dBm intercept point of the following stage. Therefore this preselector is transparent as far as intermodulation distortion of any kind is concerned. Relays are necessary to avoid distortion from the switching diodes.

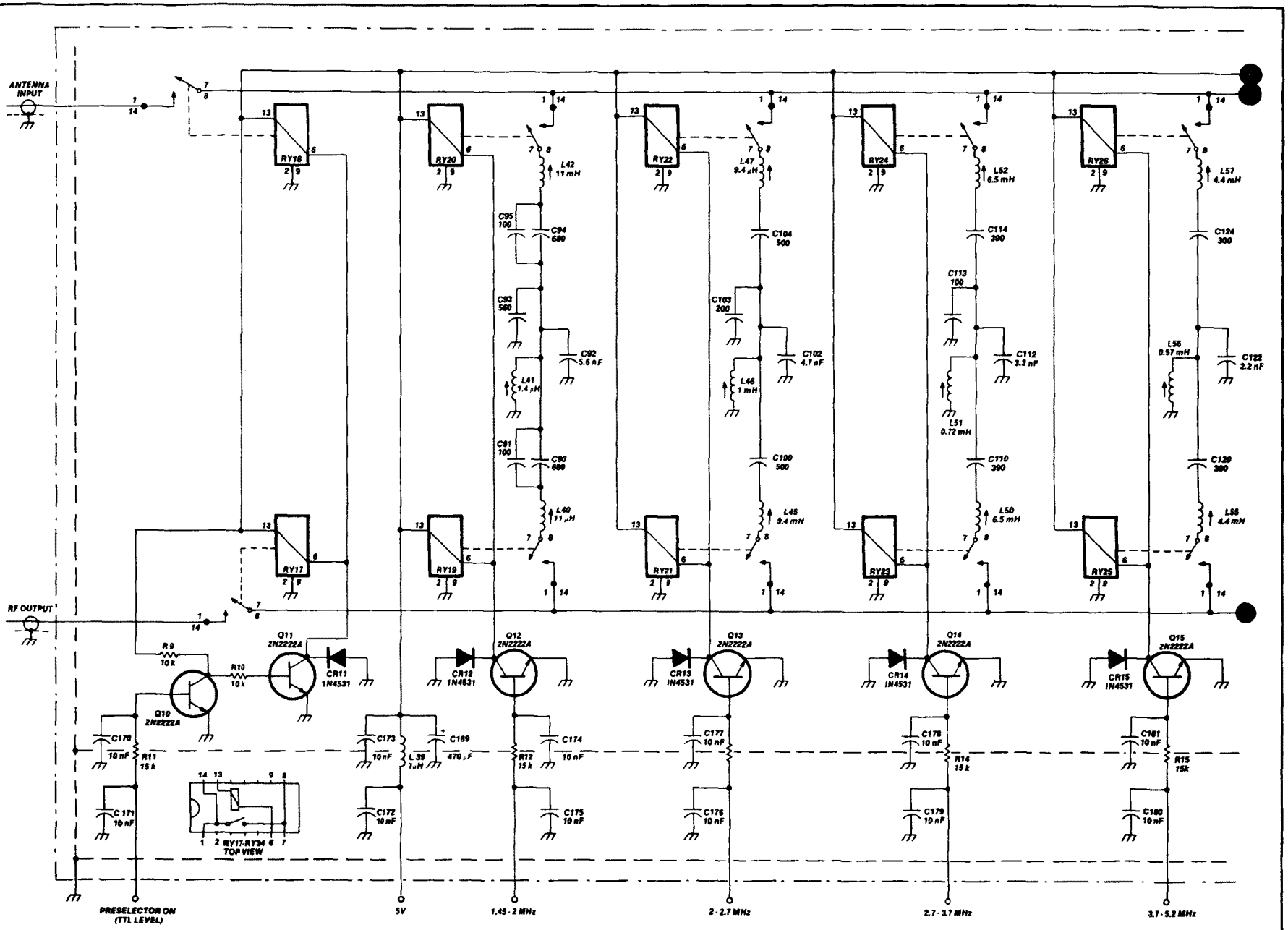


fig. 2. The rf input stage of a modern receiver using six bandpass filters and two varactor-tuned input filters.

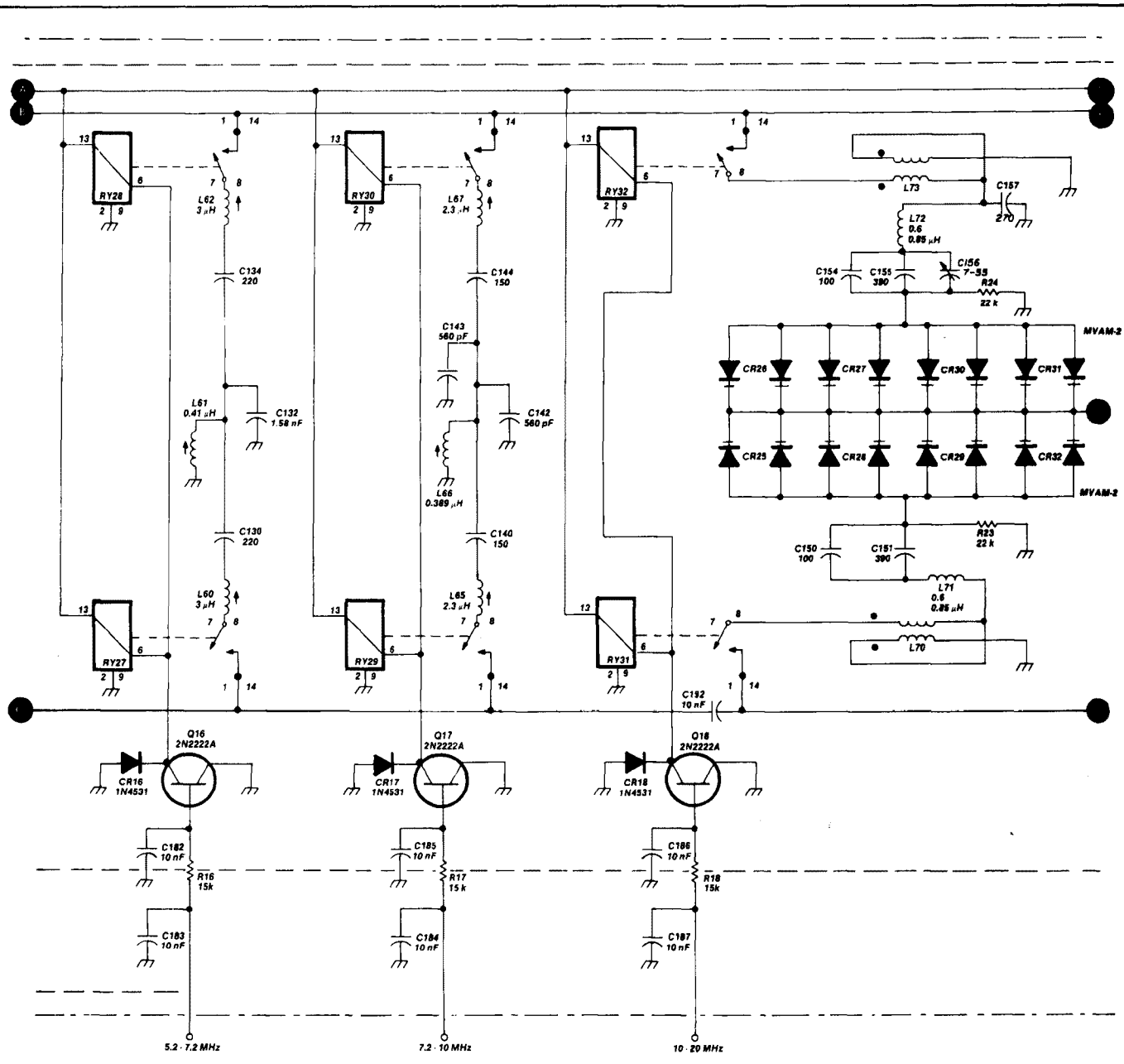


fig. 2-2. The rf input stage of a modern receiver using six bandpass filters and two varactor-tuned input filters (continued).

Similar input tracking filters are possible in the VHF/UHF range. The general finding is that PIN-diode attenuators, as sometimes used, limit the dynamic range to about +10 or +15 dBm. In transceiver application, it's possible to use the lowpass sections of the transmitter, and one has only to add highpass filter sections to obtain bandpass characteristics. The highpass sections must be calculated so that they operate together with the lowpass section (see reference 2).

input mixers

We now find a major struggle between semiconductor manufacturers and rf engineers regarding the

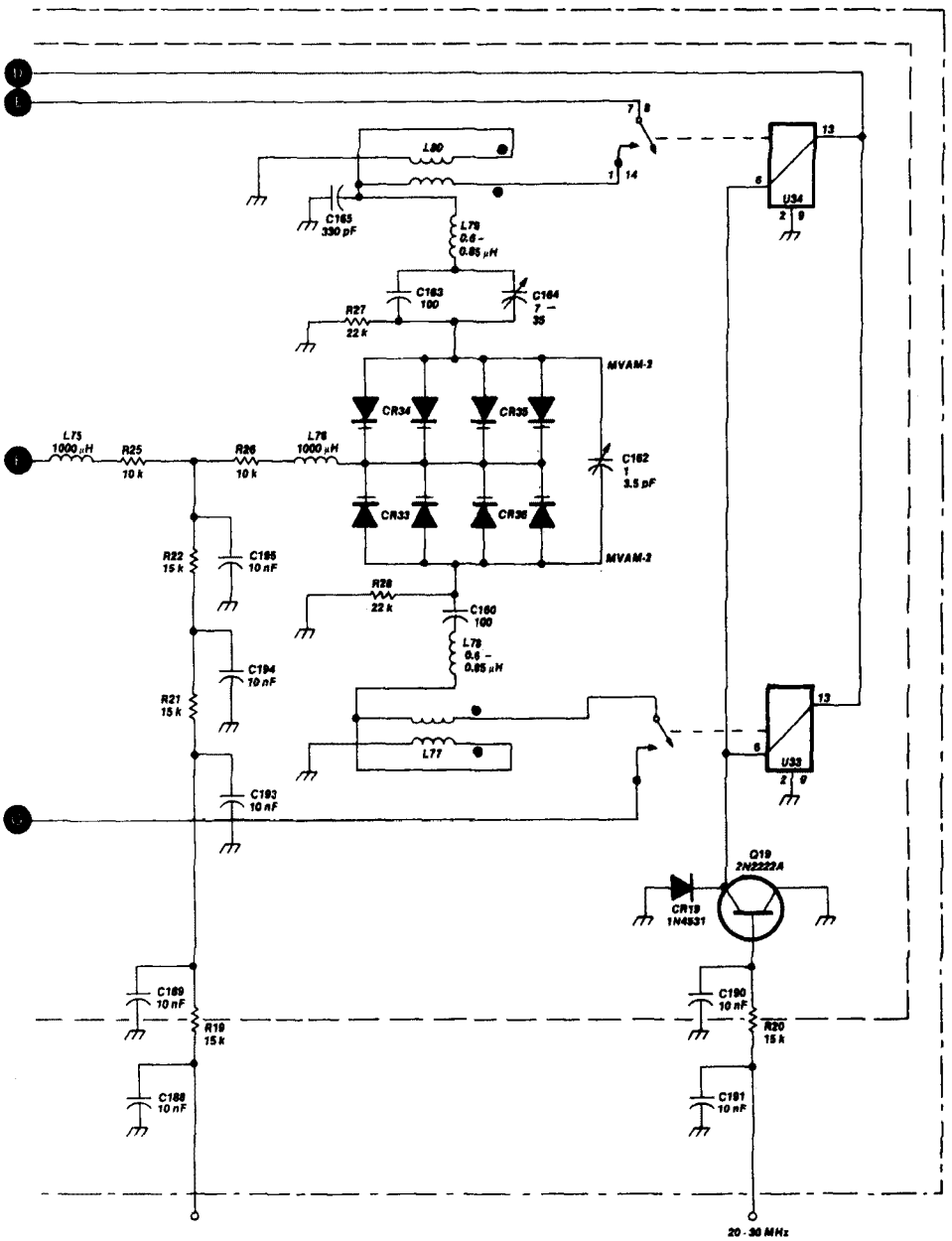


fig. 2-3. The rf input stage of a modern receiver using six bandpass filters and two varactor-tuned input filters (continued).

best mixer design. There is no question that we must use a double-balanced mixer to minimize the number of unwanted frequencies at the mixer output. Four solutions are currently available. These include the use of:

1. Bipolar active mixers.
2. Diode mixers.
3. FET active mixers.
4. Passive FET mixers in the switching mode.

Plessey has recently introducted the first really high-level double-balanced mixer, and several attempts

have been made to use it. (Probably the best summary is published in the January, 1981, issue of *QST* by Doug DeMaw.) It appears that, while the Plessey SL6440C is suitable for synthesizer or other application, its use in high-performance receivers is limited. The reason for this is discussed in the following paragraphs.

Mixer noise figure. Let's assume that the manufacturer's specifications for this Plessey device are valid: noise figure 10 dB, gain 4 dB, and intercept point +30 dBm. The mixer must operate into a stage that has a noise figure of less than, say, 3 dB. If a crystal filter or other device is inserted between the two stages, the mixer will have unity gain, as the filter losses will compensate for the mixer gain. We therefore can add the two noise figures and obtain a noise figure of 13 dB. This is done under the assumption that the stage following the first amplifier after the mixer does not contribute to the noise figure.

Let's do the same with a diode mixer, such as that developed for the HF1030 receiver, which contains two diode bridges, as shown in **fig. 3**. This mixer has an intercept point of +30 dBm, and with two signals of zero dBm applied to the input it generates two intermodulation distortion products of more than 60 dB, attenuated relative to the input signal. The mixer requires +17 dBm LO drive and has 6-dB insertion loss. The following amplifier again will have 3-dB noise figure, and, to make absolutely sure that the mixer is always terminated precisely with 50 ohms, no filters are inserted between the two devices.

As shown in my previous papers, a field-effect

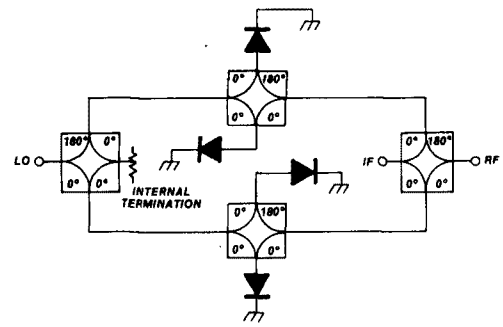


fig. 3. Schematic diagram of double-balanced mixer with two diode bridges, Model CPC106, developed for the HF1030 receiver.

table 2. Specifications of a modern VHF/UHF receiver.

frequency range	20 to 1000 MHz
frequency setting	a. quasi-continuous with rotary knob; the tuning speed increases with the speed of rotation b. from keyboard on front panel c. entered from internal memory d. entered from external computer
resolution	1 kHz/10 Hz (SSB)
readout, digital (can be shifted by 3 digits in SSB operation)	6-digit display for receive frequency, 6-digit display for frequency entered from keyboard or stored frequency value, 2-digit display for storage location
error of frequency setting	$\pm 1 \times 10^{-8}$ (or external standard frequency, 10 MHz)
antenna input	50-ohm, type-N socket
oscillator reradiation with 50-ohm termination	$< 1\mu V$ corresponding to − 107 dBm
input filters	tracking filters
frequency setting storage capacity	99 frequencies and their respective type of demodulation and i-f bandwidth
loading of storage	frequency entered from keyboard or current receive frequency, including type of demodulatio i-f bandwidth
scanning operation	up to 99 stored frequencies can be c ally scanned; halts automatically if frequency is occupied; scanning operation continued after preselected period of time at the push of a button
scanning time	Typically 50 ms per stored frequency
S/N ratio ($V_{in} = 1\mu V$, $f_{mod} = 1$ kHz, i-f bandwidth 30 kHz, af filter on)	

table 2. Specifications of a modern VHF/UHF receiver (cont.).

a-m (m = 0.5)	≥ 10 dB
fm (deviation 10 kHz)	≥ 20 dB
total noise figure (including af section)	9 dB typical
oscillator phase noise (at 20 kHz from the carrier)	120 dB/Hz typical
fm noise suppression (3-kHz deviation, f_{mod} = 1 kHz, V_{in} = 1 mV)	50 dB typical
intercept point 2nd order	50 dBm typical
3rd order	12 dBm typical
image frequency rejection	> 90 dB
i-f rejection	> 90 dB
i-f bandwidth (3 dB)	2.3 kHz, 8 kHz, 15 kHz, 30 kHz, 100 kHz, 300 kHz, 2 MHz
demodulation	a-m, fm, SSB
squelch	S/N ratio and adjustable carrier squelch circuits (both can be switched off)
af filter	300 Hz to 3.3 kHz; can be switched out
gain control AGC	i-f control for V_{in} < 80 dB (μV) rf/i-f control for V_{in} < 120 dB (μV)
MGC	i-f control 80 dB rf 40 dB; can be switch selected
AFC	digital tracking of signals of unstable frequency (can be switch off)
indication	
level	on moving-coil meter in dB (μV)
frequency offset	on moving-coil meter; sensitivity of offset meter matched to bandwidth
panoramic display	
i-f panoramic display	
sweep width	200 kHz
resolution	4.5 kHz
amplitude display	logarithmic approximately 80 dB
screen area	4 cm × 3 cm
rf panoramic display and broadband i-f display	
rf sweep width	entire reception range (500 MHz, maximum) and/or a particular section of it; superposition of frequency marker for receiver tuning
i-f sweep width	2 MHz maximum
amplitude display	linear or logarithmic 80 dB (10 dB/cm)
internal testing facilities	
continual test	monitoring of subassemblies; error signaled with code number
loop test	triggered by pressing a button; automatic testing of complete receive section including the af section and all LED displays
outputs	level, offset, af (600 ohms), a-m video, fm video, i-f (10.7 MHz, 2-MHz broadband, 50 ohms, 10 dB above input level, without AFC) i-f (10.7 MHz, narrowband, with AFC, 50 ohms, 10 mV), inputs/outputs for panoramic adapter EZP, COR (Carrier Operated Relay): coupled with squelch; dropout time internally adjustable
inputs	external control voltage, squelch response threshold
remote control (via IEC bus or RS232C interface)	all important functions, input and output

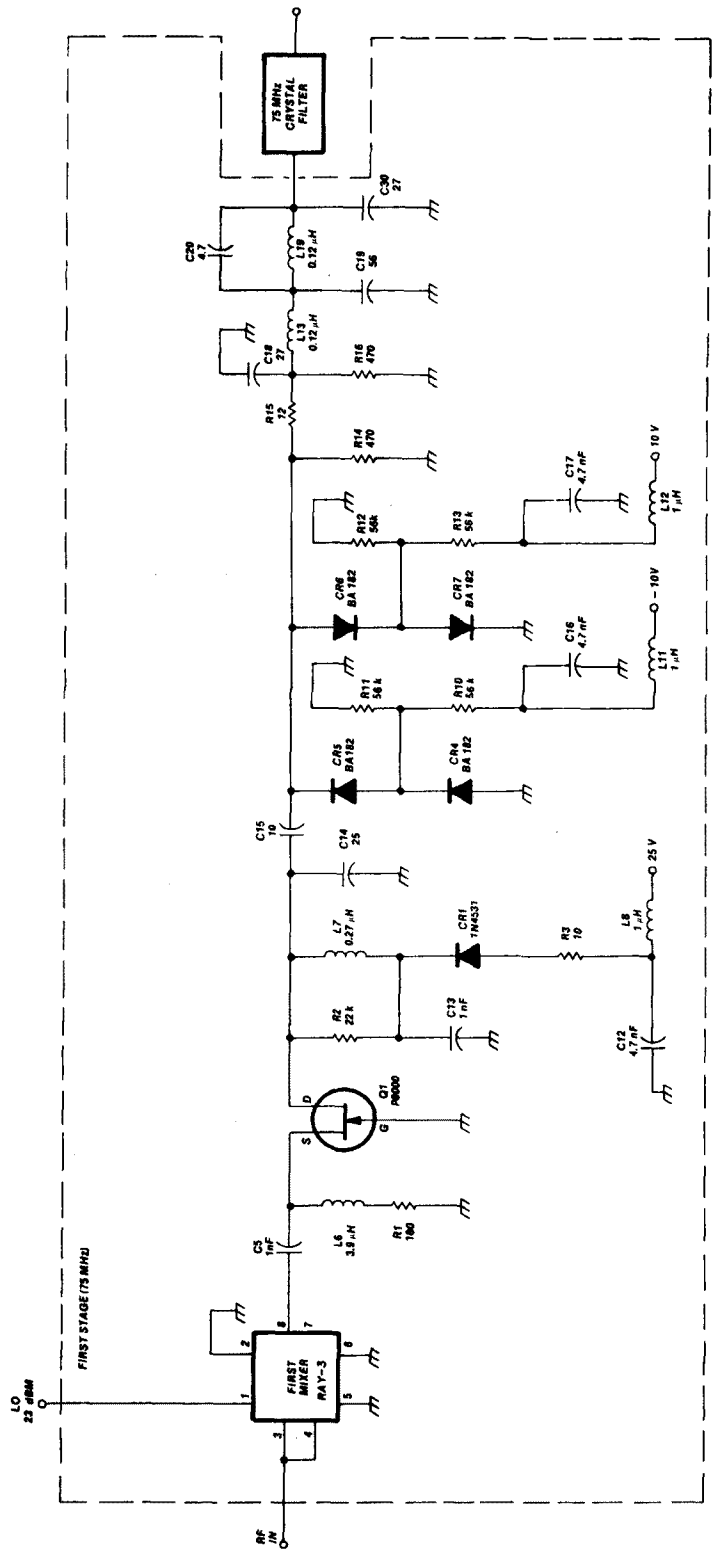


fig. 4. Input rf section of the Rohde & Schwarz ESH2 receiver.

transistor such as the CP643 operated at 20-30 mA will have about 50 ohms input impedance and will have no reactive components. This combination results in a total noise figure of 8 dB; and as the double-balanced mixer has some insertion loss, the intermodulation distortion products are now determined by *mixer performance* — not by the following amplifier.

In the case of the active mixer with the Plessey IC, even if we remove the filter and allow no noise contribution from the amplifier following the mixer, the noise figure is 10 dB, or 2 dB worse; and as the device has gain (zero dB gain is more than a 6-dB loss), we now must look at the intermodulation distortion products generated in the amplifier, which was not necessary in the previous case. Altogether, it becomes apparent that the passive double-balanced mixer, from a systems approach, is a better choice.

IMD. Let's consider the active Plessey mixer or the active FET mixer — using four FETs either in a quad package such as the U350 (apparently discontinued by Siliconix) or a dual-FET version and measure the intermodulation distortion as a function of frequency offset between the two carriers. We may be able to verify the intercept point between +20 and +30 dBm over a narrow range, but as the filter bandwidth is reached, and the input impedance of the filter following the active mixer changes, other changes also occur.

Most elliptical filters become high-impedance devices (unless simple tuned circuits are used); and as the impedance rises at the output of the active mixer, so does the intermodulation distortion product. In effect, we must sweep the mixer over the range of interest to make sure that intermodulation distortion does not occur or is at an acceptable level.

The use of a passive mixer terminated by a grounded-gate field-effect transistor, or an amplifier using the "noiseless feedback" approach, ensures intermodulation distortion products independent of frequency offset. The design of the Rohde & Schwarz ESH2 laboratory receiver combines these requirements. **Fig. 4** shows the input rf section of the ESH2, which offers this superior performance.

FET mixers. The current trend is to use field-effect transistors in the passive mode, or as switching devices in the mixer. **Fig. 5** shows a possible configuration. The FET acts as a fast switch. It has a much more defined square-law characteristic than any other device. The diode ring mixer generates its intermodulation distortion when it is about to open or close and has a high-order, nonlinear transfer characteristic; the FET does not suffer from this occurrence.

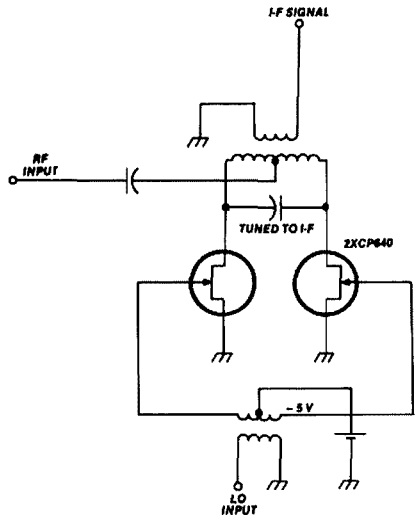


fig. 5. Passive FET mixer for extremely high intercept point.

With suitable bias applied, the intercept point can be as high as +40 dBm with little difficulty in reproduction. This technique is currently used by the Racal RA6790 receiver and by the AGC Telefunken E1700 receiver.

The disadvantage of this circuit is cost, as the LO-drive level must be as high as 23 dBm, and the matching of the device is fairly critical.

VMOS transistors have been used lately in mixers. It appears that these devices are slightly unstable. I had Doug DeMaw's mixer on loan and had some difficulties with it. Unfortunately, the ARRL wanted it for other projects, and I couldn't finish my testing; but I understand that it was tested by an independent source and they confirmed the instability if the mixer is not terminated with a pure resistance. In addition, the VMOS device, being an enhancement field-effect transistor, is slightly more noisy than the junction field-effect transistor. We are now beginning to try new circuits, including a combination of power field-effect transistors, such as the U320 or the CP640, which should give promising results.

In the second part of this article, we will look at feedback amplifiers, including the noiseless feedback circuit; i-f filters; i-f detectors; and frequency synthesizers including the fractional-N design.

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2. Anatone Zverev, *Handbook of Filter Synthesis*, John Wiley & Sons, New York, New York.

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More Details? CHECK—OFF Page 102

understanding performance data
of high-frequency receivers

Check over these definitions before you buy a new receiver

When reading manufacturer's data sheets or product reviews for receiving equipment, one encounters terms such as dynamic range and intermodulation distortion, covering essential features of high-frequency receivers but not generally known to Amateurs. Let's go through an example of high-frequency transceiver or receiver specifications and see what the terms really mean.

sensitivity

First we read that the "receiver sensitivity is 0.25 μV at 10-dB S/N," where S/N stands for signal-to-noise ratio. This information tells us that we need a 0.25-μV signal at the receiver antenna input to obtain an audio-output signal, S, of 10 times (10 dB) the audio-output power of the internally generated receiver noise, N. This value (0.25 μV) is typical for the sensitivity of a good receiver; much lower figures (higher sensitivity) are rare except in commercial grade equipment.

noise floor

The internally generated circuit noise in the receiver is usually represented as the rf input signal level that produces the same audio output power as the noise. This level is, for practical purposes, the minimum-discernible signal that can be detected in a receiver. This signal level is called the noise floor and is generally expressed in decibels below one milliwatt power, or $-$dBm. Since 0.25 μV from a 50-ohm antenna into a receiver whose input is matched to 50 ohms impedance equals $-$ 119 dBm, the noise-floor level in the example case is about $-$ 129 dBm, a common value for a manufactured Amateur high-frequency receiver. Homebuilt equipment can sometimes improve on this figure, and values below $-$ 140 dBm have been measured.

receiver noise

Receiver noise is a function of, among other things, receiver bandwidth. If we assume that the sensitivity of 0.25 μV was specified for a bandwidth (passband) of 2.5 kHz as used for SSB work, the

By Jan K. Moller, K6FM, 3653 Texas Avenue, Simi Valley, California 93063

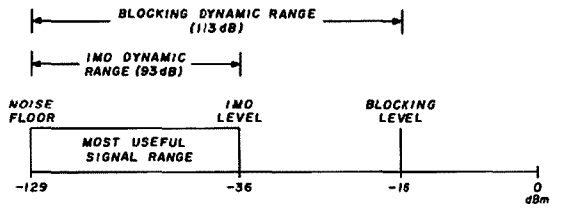


fig. 1. Performance characteristics for the receiver example discussed in the text. Shown are IMD dynamic range (93 dB) and blocking dynamic range (113 dB).

reduction of the bandwidth with a filter for CW to, say, 500 Hz, will improve the receiver's apparent sensitivity. The reason is that, by reducing the bandwidth five times, you reduce the amount of noise coming through the receiver and effectively lower the noise floor 7 dB. The new level, in our example −136 dBm, makes it possible for you to receive a correspondingly weaker CW signal, about 0.1 μV, with the same 10-dB signal-to-noise ratio as the SSB signal first mentioned. Anyone who has operated such a narrow bandwidth receiver will remember how quiet it seems and how you can pick out really weak ones.

IMD and desensitization

The ability of a receiver to handle a wanted signal in the presence of strong adjacent signals is of greatest importance in today's crowded Amateur bands. Two phenomena are most significant, intermodulation distortion, or IMD, and blocking, or desensitization of the receiver. IMD is caused by the mixing, because of imperfections in the receiver front end, of wanted with unwanted signals outside but near the receiver passband. The result is interfering signals in the passband; most dominantly they are the third-order mixing product of two unwanted signals. (Example: two unwanted signals with frequencies f_1 and f_2, mixing product $f_i = 2f_1 - f_2$; if $f_1 = 14{,}060$ kHz and $f_2 = 14{,}040$ kHz, then $f_i = 14{,}080$ kHz. The same is true for $f_i = 2f_2 - f_1 = 14{,}020$ kHz.)

IMD dynamic range

Returning to the sample specs — they state that "third order IMD is better than −36 dBm." According to definition, this says that, if the receiver is tuned to frequency f_i, a resulting signal of this frequency will be audible 3 dB above the receiver's noise level when incoming signals f_1 and f_2 are at the −36 dBm level (about 50 dB over S9). Such a weak f_i signal is just barely recognizable in the noise. This information permits the calculation of IMD dynamic range, the difference between the noise-floor level and the IMD measured level; here it is 93 dB for an SSB bandwidth.

This number is one of the most important characteristics of a receiver in that it specifies the range of signals that can be handled with essentially no undesired spurious responses. Other effects, such as blocking and crossmodulation, occur mainly outside this range of signals, see fig. 1. A good receiver is expected to have an IMD dynamic range of at least 80-85 dB, and slightly better for a CW bandwidth.

The IMD effect is basically caused by the mixer, and one measure of receiver performance is obtained in the following manner. If the mixer i-f output of the desired signals, as well as the IMD product, are plotted against rf input, the two lines will intersect at a certain output level, fig. 2. Note that the two straight lines will have to be extrapolated to intersect, as this usually occurs at such high rf input levels that mixer gain compression (see below) takes place. The intersection level of output is called the third-order or IMD intercept (point), and is expressed in dBm. This point defines essentially the intermodulation performance of the receiver front end for all signal levels and thus becomes a figure of merit. Typical IMD intercept values range between −5 and 25 dBm — the higher numbers indicating better performance.

gain compression and blocking

Blocking, or desensitization, is the result of a very

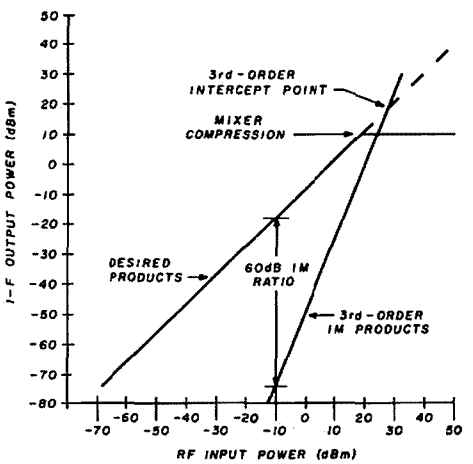


fig. 2. Third-order intercept point is determined by extrapolating the desired product curve beyond the mixer compression point and intersecting it with the third-order IM-product curve. (From the *ARRL Radio Amateur's Handbook*, 1981.)

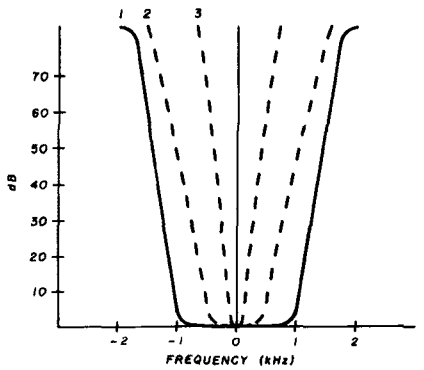


fig. 3. Typical i-f response curves. Curve 1: Built-in 2.4-kHz filter. Curve 2: Added 500-Hz filter. Curve 3: Alternate 250-Hz filter.

strong signal outside the receiver's i-f passband causing loss of gain; that is, gain compression. The blocking signal level is defined as the rf input voltage 20 kHz off frequency that causes the audio output of a weak desired signal (S5 or so) to drop by 1 dB. Typical signal levels are 20-25 dB above the third-order IMD level but this quantity is rarely stated in receiver specifications. Sometimes the expression "blocking dynamic range" is used. This is the difference between the noise floor level and blocking signal level. In the example case, this value typically would be 113-118 dB (related bandwidth should be stated).

cross modulation

Cross modulation occurs when the modulation of an adjacent strong signal appears on a desired strong signal in the millivolt range. The effect is rarely measured for Amateur receivers, where the interest is centered on small-signal performance. Also, IMD products would probably have been encountered in the receiver during such operating conditions. Many modern receivers contain a switchable front-end attenuator to minimize the unwanted effects of strong-signal reception.*

SSB selectivity

The sample receiver specs state that the receiver SSB selectivity is "2.4 kHz at −6 dB and 3.6 kHz at −60 dB." These numbers show a) the width of the receiver passband at 6 dB below the peak of the i-f curve (2.4 kHz) and 60 dB down from the peak (3.6 kHz) and b) the depth and the shape or form factor of the gate through which your desired signals can pass, fig. 3. The shape *factor* is defined as the ratio between the receiver bandwidth at −60 dB and −6 dB; in this case it is 1.5.

Receiver selectivity is largely established in the i-f circuits and, depending upon the characteristics of the i-f filters and signal leakage, the passband curve can be quite narrow and have steep sides down to 80 or 90 dB below the peak. A steep curve with sides going as low as possible before flattening out is desirable in that adjacent i-f signals are better suppressed, causing less interference and background hash. A receiver with a square-shaped passband curve down to −90 dB will appear much quieter than one that begins to flatten out at *−60 dB*.

CW selectivity

For CW operation, most high-quality receivers offer a number of narrow passband options, which are achieved by installing additional i-f filters. One of the example receiver options provides a selectivity of 500 Hz at −6 dB and 820 Hz at −60 dB. These values are average narrowband figures, and an experienced CW operator may even choose a higher selectivity such as 250 Hz at −6 dB and 500 Hz at −60 dB. Similar options exist for SSB operation by i-f filter replacement, but the bandwidth is rarely reduced below 1.8 kHz at −6 dB because of loss of voice quality. Instead, efforts are made to make the i-f passband steeper and improve out-of-band i-f signal suppression with more complex filters, possibly cascading several units.

image suppression

Because most Amateur communications receivers are superhets, two specifications relate directly to their conversion design. In the mixer, the undesired sum (or difference) of incoming-signal and local-oscillator frequencies, the image signal, is suppressed by the combined action of a high first i-f, the tuned circuits preceding the mixer, and good shielding. The sample specs state, "Image ratio better than 60 dB," which is entirely sufficient for Amateur use, in which most antennas are tuned to the operating frequency or a harmonic thereof.

i-f rejection

The receiver i-f is also susceptible to false signal pickup. The i-f circuit shielding and the tuned circuits before the mixer (tuned to the desired signal frequency) prevent outside signals at the intermediate frequency from entering the receiver. According to the sample specs, "i-f rejection better than 80 dB," a very satisfactory value, as the i-f is not a harmonic of, nor does it fall on, any Amateur band.

frequency stability

One essential quality is frequency stability. Modern solid-state oscillators have largely overcome stability

*Try reducing the rf gain. Most receivers have an rf gain control. Editor

problems in Amateur equipment. The example receiver specifies frequency stability as, "Within 100 Hz during any 30-minute period after 1 hour of warm-up." This magnitude of drift would, at most, appear as a very, very slow change of tone pitch, barely noticeable on CW, and would be entirely satisfactory.

summing up

Of all these performance characteristics, which are the most important? Well, I live near Los Angeles, where a lot of strong local signals seem to fill every DX band.

After I determined that the transceivers I was interested in comparing had the desired bands, digital frequency readout, and other general features, the first special consideration I looked for became the receiver's blocking characteristics and IMD dynamic range. Fortunately, this matter has recently been given a great deal of attention by two competing manufacturers of high-frequency transceivers, as well as the ARRL product review team. Consequently, the data were readily available in *QST* and from the manufacturers and their data sheets.

My second special consideration was receiver selectivity. A basic SSB passband curve with a shape factor of 1.5 or less and straight sides down to −90 dB or lower would be most desirable. Additionally, a front-panel, switchable, narrowband CW filter with narrow bandwidth is a must. Should the receiver also have variable i-f bandwidth control, so much the better. The third special consideration is mechanical rigidity and front-panel layout.

I gave items such as sensitivity, image and i-f rejection secondary consideration, mostly because, in today's competitive market, solid-state circuits have almost universally forced to the fore good designs. The better high-frequency transceivers all seem to have more than enough sensitivity and, instead, become limited by atmospheric and manmade noise when in actual use.

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- DRAKE TR-7 with DR-7

AMPLIFIERS
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More Details? CHECK—OFF Page 102

ham radio TECHNIQUES

Bill Orr W6SAI

One of the nicest aspects of writing for *ham radio* is the interesting mail I receive. There's always something new in antennas, and this column is partially devoted to unusual antenna designs sent to me by other Amateurs. Let's start with an interesting 2-meter antenna from "down under."

the SLY beam

The SLY (Suspended Long Yagi) beam for 2 meters was developed by VK4ALE (now a Silent Key) and described in a recent issue of *Amateur Radio*, the excellent journal of the Wireless Institute of Australia. Briefly, the SLY beam is an inexpensive, portable Yagi antenna for Field Day operation. A plan view of the SLY antenna is shown in **fig. 1**. The supporting structure is made of two spreaders between which lengths of Dacron line are strung. (Nylon line should not be used because it stretches and causes the antenna to sag. It is also expensive.)

The Yagi elements are spaced along the two lines as shown and are held in position by small elastic rings cut from neoprene tubing (or similar dielectric material). The elements can be slipped into position and adjusted, as the rings provide a positive grip to the line yet permit easy movement of the element if required.

The two lines are attached to wooden spreaders, which are suspended in position with rope halters. The beam is pulled up into position between two fixed points and the halter ropes tied off.

Number of elements and feed system? Well, VK4ALE used 20, 25, and 30 elements at various times and even tried 32 elements—the overall length of the Yagi being about 75 feet (23 meters). Measurements on the 32-element job indicated a power gain of about 21 dB over a dipole, and the measured beam pattern at a distance of 200 miles was 35 miles wide (322 and 56 meters respectively). Not bad performance for an inexpensive, portable antenna.

One-eighth-inch (3-mm) aluminum tubing is suggested for the elements, or aluminum clothesline wire can be used. Element lengths and spacings used by VK4ALE are given in **fig. 1**, or Yagi dimensions provided in the various publications[1,2] can be used. Any of the common feed systems are applicable.

VK4ALE suggests that the completed beam be rolled up on a lightweight drum or cylinder for ease of transport, otherwise problems may be encountered in unravelling the assembly.

help for the beginner?

Alas, life grows more complex, even against our best intentions. VK5EK brings our attention to that particular folly in his letter to the editor published in a recent issue of *Amateur Radio*. Al speaks about a low-power, solid-state transmitter design, *similar* to the one shown in chapter 6 of ARRL *Handbook*.

Al says, "If we are trying to overcome the 'black box' syndrome by inducing people to build their own equipment, then we will maximize our chances of success by presenting simple, cheap projects.

"Good applied engineering is concerned primarily with securing a stipulated design objective in the simplest and cheapest manner.

"Your 5-watt CW transmitter fails dismally in this regard, and is a stunning example of solid-state technology gone berserk.

"I present an alternative circuit which will do the same job (**fig. 2**). Your circuit has about 100 components, mine has fewer than 25. Most of your components would be purchased new; most of mine can be salvaged from an old black and white TV set (save the crystal and plate-tuning capacitor). I could build mine from scratch and have it working in one hour if I set my mind to it, or I would take two or three hours if I wanted a pretty appearance. Yours could hardly be built in less than four or five nights. You price yours at $50 (including crystal). I price mine at nil cost (excluding crystal and assuming a modest junk box).

"Your rig has a VXO and the capability for battery operation, which mine does not; but mine will readily work into any standing-wave ratio.

"Solid-state technology affords commercial manufacturers cheap, large-scale production and it is ideally suited to logic and nonlinear applications. But for transmitters, transverters, receivers and converters of practical simplicity, valves (tubes) remain incomparably superior for one-of-a-kind, home-built projects."

yesterday's technology

An interesting viewpoint indeed!

It is certainly true that tubes and old-time components, including defunct television receivers, are readily available at flea markets. In fact, *QST* magazine has run several articles in the past on using TV components salvaged from old, defunct receivers to build ham gear. And it is also true that some circuits can be built more inexpensively and quickly using tubes.

However, VK5EK misses one important fact of life that cannot be denied, and that is that the great majority of today's Amateurs have been brought up in a solid-state world and vacuum-tube technology is alien to them. It may seem simple to old timers, but tube technology can be puzzling and obscure to many of today's younger Amateurs. Vacuum-tube technology is no longer taught in colleges, and information on tubes is rapidly disappearing from Amateur magazines and handbooks. So while VK5EK has a valid point in extolling vacuum-tube simplicity, he is talking to an audience that, sadly, is deaf to his plea.

While I am on the soap-box, I might as well discuss another bête noire of Amateur Radio: amplitude modulation. A-m, or "ancient modulation" as it is derisively called by some, has largely disappeared from the Amateur bands. That allows a great improvement in spectrum conservation, and the loss of heterodyne interference between phone carriers is a tremendous step forward in improved communications ability.

But an unwanted effect of sideband use is that amplitude-modulation techniques are largely unknown by today's Amateurs. How many recently licensed Amateurs have knowledge of a class-B plate modulation system? Or the more recently developed pulse-duration modulation technique? Or the various high-efficiency amplitude-modulation systems including grid modulation? Or the famous Doherty-modulated amplifier?

Like it or not, a large percentage of

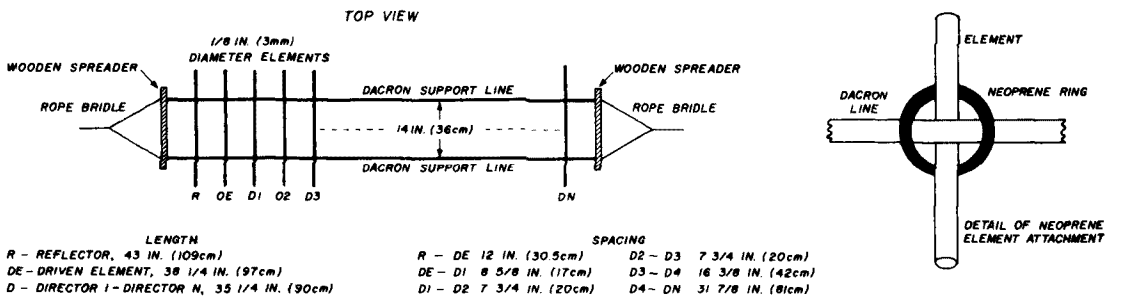


fig. 1. The SLY (Suspended Long Yagi) array of VK4ALE has been built with as many as 32 elements. This compact, flexible 2-meter beam is suspended from two Dacron* lines run between wooden spreaders. Directivity is to the right. All elements are held in position along the lines by rings cut from flexible Neoprene tubing. VK4ALE's dimensions are shown, but other refieble beam dimensions may be used. The driven element, DE, is fed by conventional means.
Any non-stretch line may be used. *Editor

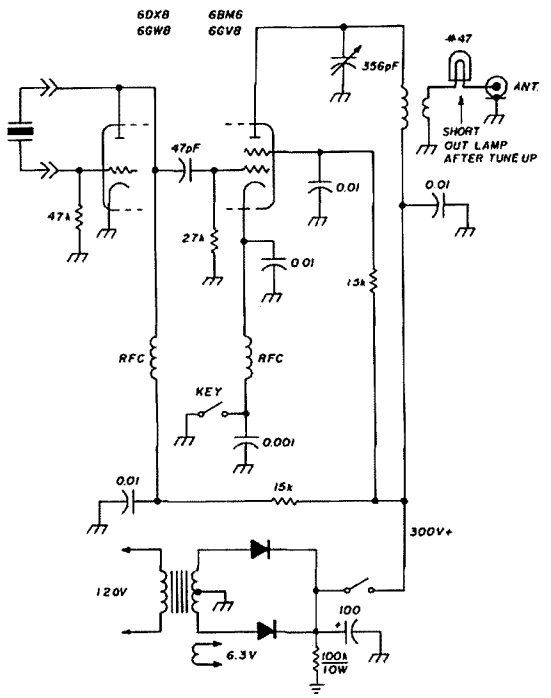


fig. 2. VK5EK's tongue-in-cheek reply to the modern QRP solid-state transmitter. Why use six expensive transistors and about 100 components when one tube and two diodes, plus a handful of flea-market components will do the job? Old-timers will certainly remember low-power transmitters of this general type. (Drawing adapted from *Amateur Radio* magazine, a publication of the Wireless Institute of Australia.)

communication in today's world is carried on by amplitude modulation. You don't believe me? Then just tune across the broadcast band or the many shortwave broadcast bands. All of these signals are amplitude modulated.

Banning amplitude-modulated signals from the Amateur bands might be a movement toward spectrum conservation, but it would further restrict the Amateur's knowledge in an important technology that forms a large portion of today's communication world. Plenty of space exists on 160, 10, and 6 meters for amplitude-modulation equipment, and it would be unwise to ban this basic form of intelligence transmission from the world of Amateur Radio.

a 5-band sloper antenna

Here's an antenna that works well on all bands. It was shown in *The Canadian Amateur* magazine[3] and designed by VE3CPU (**fig. 3**). Basically, it is one-half of a regular trap dipole antenna. A metal tower is used as a ground counterpoise. Only one trap is required, so a trap kit can be split with a friend who also wants to build this simple antenna. The antenna is fed with a coaxial line, the shield of which is grounded to the tower and the inner conductor is attached to the sloper wire.

VE3CPU points out that the antenna is quite directive on the higher-frequency bands, and swinging the bottom of the antenna about 90 degrees makes a big difference in signal strength at a distant location. He estimates the power gain over a dipole to be about 2.5 to 3.0 dB on 20, 15, or 10 meters.

As with all slopers and multi-band antennas, adjustment of the length of the tip section may be required to resonate the antenna at the design frequency on 80 meters.

radio-frequency interference (RFI)

RFI! It's hell if you have it. It can ruin your enjoyment of Amateur Radio by interfering with television and radio reception, disrupting communication circuits, causing false beats in electronic heart pacers, and by causing all other manner of equipment malfunction. Radio Amateurs are at once the cause and victim of RFI, as are CBers and all other users of electronic equipment.

Look at these numbers. In the United States in 1980 there were more than:

- 8,200 broadcast and fm stations
- 970 television stations
- 15,000,000 CB transmitters
- 360,000 Amateur Radio stations
- 210,000 aviation transmitters
- 7,800 radar transmitters
- 300,000 industrial radio transmitters
- 115,000 police and fire department radio transmitters
- 36,000,000 two-way portable radio transceivers plus millions of microwave ovens, X-ray machines, electric motors, light flashers and dimmers, welding machines, neon signs, diathermy machines, plastic formers, industrial welders, and so on.

And that's not all. Radio and television receivers themselves can cause objectionable RFI! The problem is that all radio receivers, transmitters, and pieces of electronic equipment are potential sources and victims of RFI. Anything run by electricity can cause RFI.

No wonder that electronic bedlam surrounds us, and it is a wonder that anybody can hear anything on the radio or see anything on television

considering the vast number of interference-generating devices in our environment.

the sources of RFI and the *victim*

Remember, all cases of RFI involve two things: the source of the interference and the victim of the interference. For a complete cure of RFI, the interference must be suppressed at the source and the victim (the receiver, stereo equipment, or whatever) must be protected, or otherwise modified in such a way as to reject the interference. This is a large order, and little is being done to solve the growing problem. Information about RFI and its cures is hard to come by, RFI sources are obscure, and a lot of misinformation compounds an otherwise complex problem.

the RFI investigator

In recent years a whole new industry has grown up, largely unknown to most Radio Amateurs: the investigation and suppression of RFI. Electromagnetic compatibility studies and control standards have been created, largely by the military, to safeguard their communications circuits. Courses are available on electromagnetic compatibility and a new career opportunity — that of RFI investigator — has opened up for select, knowledgeable individuals. The job of the investigator is to investigate RFI complaints, track the interference to its source and resolve the problem. Only a handful of RFI investigators are at work in the United States today.

One of the pioneers in this field is a Radio Amateur, Bill Nelson, WA6FQG, who is well known nationwide for his extensive work in RFI investigation, encompassing over two decades of experience. During his long career, WA6FQG has tracked down countless sources of RFI and has lectured to Amateur and CB clubs and conventions on the causes and cures of RFI. Bill is now a consultant to power utilities on RFI problems, including RFI suppression and training of RFI investigators.

Just recently Bill completed an all-inclusive handbook on RFI, which covers the subject in detail.* It is an indispensable reference for all Radio Amateurs, CBers, and the everyday citizen troubled by RFI.

I've personally known WA6FQG for many years and have been *greatly* interested in his career in this unique work. And I have helped him arrange his handbook and get it published. It's now ready — over 240 pages of valuable information dealing with all facts of RFI.

An advance copy of the *Interference Handbook* was sent to Barry Goldwater, K7UGA, (U.S. Senator from Arizona and Chairman, Senate Communications Subcommittee). After reading the book, Barry said, "This informative handbook covers the entire field of RFI from A to Z. It will be a tremendous help to me and my staff as we work on communications legislation in Congress. Thanks for your help in this matter."

Another accolade for the new *Interference Handbook* came from David Fogarty, Senior Vice President of Southern California Edison Company. He said, "Written by a power-company investigator with 33 years of experience, this book is a reliable guide to the causes and cures of power line interference . . . contains absorbing case histories."

So there you are. Perhaps this new handbook will help you with your RFI problems. As I said before, RFI is hell if you have it. And if you don't have it today, chances are you will have it tomorrow!

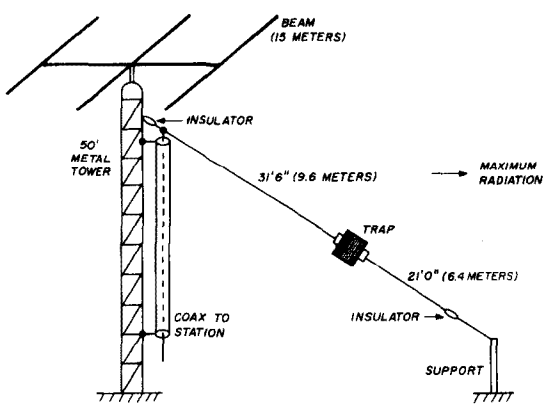


fig. 3. The 5-band sloper antenna of VE3CPU as described in reference 3. The antenna is used on bands between 10 and 80 meters. It is one-half of a regular trap dipole using a metal tower as a ground counterpoise. One trap dipole kit makes two antennas, so you can split a kit with a friend who also wants this antenna. Braid of coax is grounded to top and bottom of tower, and center conductor connects to the sloper wire.

**Interference Handbook*, by William R. Nelson, WA6FQG; Editor William I. Orr, W6SAI; 247 pages; $8.95 plus $1.00 shipping — available from Ham Radio's Bookstore, Greenville, New Hampshire 03048.

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ham radio

add-on selectivity for communications receivers

A new audio filter design featuring sharper cutoff for SSB and better skirt selectivity for CW

The message of this article is that really effective audio filtering can work wonders to improve the performance of today's high-frequency receivers. First, however, we must consider just what the problems are that have to be solved.

A fact of life in high-frequency communications today, especially on the Amateur bands, is congestion. The problem is probably most acute for Amateur SSB transmissions. For a number of reasons, ranging from changing propagation conditions to sheer congestion, it's rare for an SSB station to have an undisturbed channel for long.

SSB interference

Normally, one SSB signal overlaps to a greater or lesser extent with others. The overlap can vary all the way from two stations being on identical frequencies to a medium overlap, where the off-tune interfering station causes characteristic high-pitched "monkey chatter." This can be either in the background or the foreground, depending on the relative strengths of the desired and undesired signals. Off-tune interference on the other side of the passband similarly causes a low-pitched version of monkey chatter. Other interference frequently encountered during SSB operation includes overlap with out-of-band intermodulation products (splatter) from over-driven and hence nonlinear SSB power amplifiers, single heterodyne whistles, CW and RTTY transmission, and broadcast stations operating in Amateur bands (particularly on the 40-meter band). Other kinds of strange noises come and go, ranging from the notorious Russian woodpecker to common interference from local electrical equipment.

CW interference

The effect of congestion on CW Morse code transmissions is similar in the sense that all the same interference sources are common. A difference is that CW transmissions don't actually overlap each other to any noticeable extent (sending speeds are low enough that sideband spread is very slight). On the

By Dr. D. A. Tong, G4GMQ, Datong Electronics Limited, Spence Mills, Mill Lane, Bramley, Leeds LS13 3HE, England

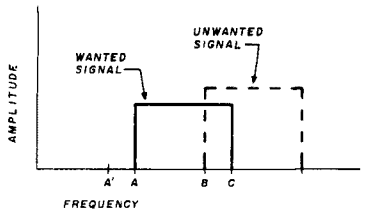


fig. 1. Solid curve shows frequency band (A to C) occupied by desired signal. The dashed curve represents the band occupied by a partially overlapping interfering signal. For optimum separation of the two signals, the receiver should accept only signals between A and B, and the cutoff at frequency B must be as sharp as possible. Point A′ is the distance that the lower cutoff, A, would move in so-called passband tuning (see text).

other hand, congestion causes the separate CW transmissions to be very close together and spacings of 200 Hz and less are not uncommon.

Users of other less-common transmission modes, such as radioteletype (RTTY) and slow-scan television (SSTV), are also affected by the same interference sources and are possibly even more vulnerable since the raw data is not prefiltered by the human brain before its message content is processed.

Another important source of interference is pulse noise, typically from car ignition systems, but this will not be considered further here since noise-blanking systems handle this kind of interference very effectively.

From the discussion above we can distinguish the following separate interference situations:

1. Broadband interference affecting a broadband transmission.

2. Narrowband interference affecting a broadband transmission.

3. Broadband interference affecting a narrowband transmission.

4. Narrowband interference affecting a narrowband transmission.

Each of these four cases requires different countermeasures if the receiver is to give the best possible separation of desired from undesired signals. Let's now consider these requirements in turn.

case 1 — broadband signals, broadband interference

This situation presents the most difficult problem and is typified by an SSB speech signal with other off-tune SSB signals superimposed. The situation can be represented as in **fig. 1**, in which the solid curve shows the typical frequency band occupied by the wanted signal, while the dashed line shows that of an interfering signal. Clearly, the amount of interference experienced will depend on the receiver bandwidth. The distance from **A** to **C** represents the normal receiver bandwidth (typically 2.1 kHz). If the bandwidth were reduced to **AB**, then all the interference would be eliminated with only slight effect on the desired signal.

To obtain maximum benefit from a bandwidth reduction under these conditions, it's essential that the cutoff at the edge of the passband be very sharp. A slow cutoff would give a greater reduction in the wanted signal for a given reduction in the interfering signal. A cutoff at least as sharp as that of a multipole crystal filter is desirable.

An alternative to merely shifting the upper cutoff frequency of the filter passband (that is, **C** to **B** as above) is to shift the whole filter passband. This is the so-called i-f shift, or passband tuning technique. Then, if the upper cutoff point moves from **C** to **B**, the lower cutoff would move an identical distance (that is, **A** to **A′** in **fig. 1**). This will remove the interfering signal; but it will also allow signals on the other side of the desired signal to enter the passband. Since the desired signal will normally have interference on both sides, i-f shift is only a partial solution.

We conclude, therefore, that for receiving broadband signals in the presence of broadband noise we need:

1. Independently adjustable upper and lower cutoff frequencies.

2. Very steep sides to the overall response curve — at least as steep as those in SSB-type crystal filters and preferably steeper.

case 2 — broadband signals, narrowband interference

Here the typical example is SSB reception in the presence of a loud whistle. If the frequency of the whistle is near the edge of the desired audio frequency response, a filter of the type discussed in the previous section can be used. However, if the whistle is near the middle of the audio band, decreasing the upper cutoff frequency (or increasing the lower one) will remove the whistle — but will also eliminate too much of the desired signal.

A better solution here is to use a notch filter. This is a filter that passes all frequencies except a narrow range centered on the notch frequency. By moving the notch until it coincides with the undesired whistle, the latter can be removed without significantly affecting the desired signal.

The conclusion is, therefore, that we need a narrow-bandwidth notch filter whose center frequency can be tuned over the full receiver bandwidth. A self-tuning notch filter designed especially for this purpose, the Datong Model FL1, has been described (reference 1).

case 3 — narrowband signal, broadband interference

The narrower the desired signal, the easier it is to filter it from broadband interference. Consider, for example, two transmissions with equal peak power. One is a CW signal; the other a SSB speech signal. The energy in the latter is, on average, spread over a bandwidth of typically 2.4 kHz (the so-called speech bandwidth), while that in the former is concentrated on *one* frequency (assuming normal sending speeds). If the CW signal is passed through a filter of 200-Hz bandwidth, all of the CW signal will pass through, but only 200/2400, or one twelfth, of the SSB signal will emerge.

Now, if the bandwidth is then narrowed to only 50 Hz, the ratio becomes 1:48. The point is that, provided the bandwidth reduction does not encroach on the frequency components in the desired signal, a continuous improvement in signal-to-noise ratio will result as the bandwidth is reduced.

In the case of CW signals, the minimum usable bandwidth depends on the sending speed. Reducing the bandwidth increases the rise and fall times of the dots and dashes. When these rise and fall times become comparable to the duration of a dot, the dots merge into each other and the signal becomes a blur. At typical sending speeds this blurring effect does not cause problems until the bandwidth is below 50 Hz, so that, compared with a receiver using a SSB-width filter (say, 2.4 kHz), an improvement approaching 50 to 1 is practicable through bandwidth reduction. This is why a good CW filter can easily retrieve a CW signal that's almost buried in a SSB signal when listening using only the SSB filter.

case 4 — narrowband signal, narrowband interference

The most common example of this condition is two closely spaced CW signals. Any of the filtering methods described so far are suitable in principle. For example, a wide passband could be used but positioned to just cut off the undesired signal; or a notch filter could be used to remove it. However, conditions seldom remain constant for more than a few seconds, and one interfering signal can soon be joined by many others. Because of this problem, it's convenient to use a narrowband filter centered on the signal of interest. Some operators prefer to use a passband with a pointed top, while others may prefer a more rectangular shape. The latter can be useful in net operations where not every station is exactly on the correct frequency.

Also subject to personal preference is the question of skirt selectivity. Some operators prefer to hear only the signal of interest (that is, single-signal reception); others prefer to have some indication of what is present on adjacent frequencies.

Before summarizing the requirements for a CW filter, we must consider the question of how the filter is controlled. For SSB reception, separate adjustment of the upper and lower cutoff frequency is desirable. For CW reception, this is not ideal. It's much better if the center frequency of the passband and the passband width can be separately and smoothly varied and in such a way that the two controls *do not interact*. Thus one should be able to select a particular bandwidth and move this constant-width window to any point in the overall receiver passband. Because of the very wide range of conditions that are likely to be encountered, CW filters having continuous adjustment are far more effective and pleasant to use than those with a limited number of switched settings.

In summary, for CW reception the following features are desirable:

1. The receiver bandwidth should be continuously and independently adjustable in width and center frequency.

2. The filter pass-band shape should be selectable between flat and peaked.

selectivity at i-f or af?

Conventionally, most of the selectivity in a receiver is concentrated at the intermediate frequency (i-f). This is a matter of practical convenience. It's easier to make an effective high-frequency filter if its frequency is fixed, and this is why the superheterodyne receiver rapidly superseded the tuned-radio-frequency (TRF) type.

Provided a receiver is linear throughout, the overall selectivity is the product of *all the separate sections in the system*. Thus, in a SSB/CW receiver all stages, including the final detector are, in theory at least, linear; and the selectivity could be located in the rf, i-f, or audio sections with equal effect. In practice, however, it's desirable to have *as much selectivity as possible as near to the input as possible*. This is because real circuits, especially mixers, are not perfectly linear, and strong unwanted signals can combine to form mixing products that can interfere or obscure the desired signals.

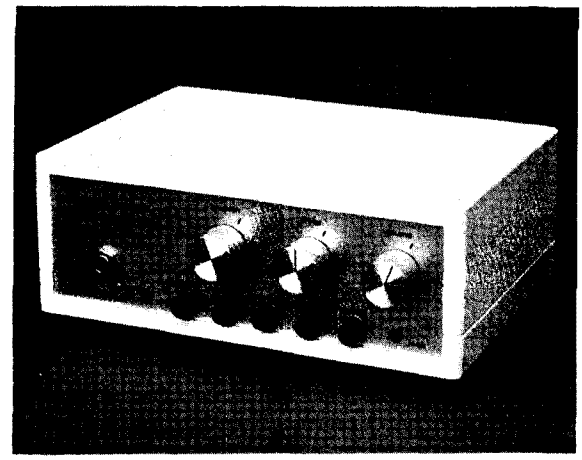
In most modern receivers, a good filter is used at the i-f, and an automatic gain control system is used to control the gain ahead of the main filter to avoid

overload effects. This means that extra selectivity can be placed at *any point* in the receiver system *after* the main filter without running into problems caused by overload. Thus, by taking advantage of the protection afforded by a good SSB crystal filter and good AGC, an audio filter can be used very successfully at the output of a receiver. If the audio filter's bandwidth is less than that of the main filter, the overall receiver bandwidth will then be controllable *by the audio filter.*

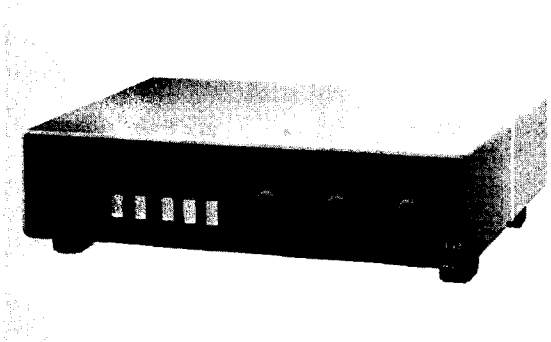
is audio filtering really as effective as i-f filtering?

The short answer to this question is yes, whenever a product detector is in use (for example, for CW, SSB, RTTY, or a-m received as SSB). When a linear detector is used (that is, a product detector), selectivity after the detector is exactly equivalent to selectivity before the detector. So that, for example, if you wish to separate two signals of slightly different frequency you could do it equally well before or after such a detector. On the other hand, when the same signals are processed by an envelope detector (as for normal a-m), the two signals emerge mixed with sum and difference products. Thus, although very useful results are obtained, a complete separation is not possible using filtering after an envelope detector.

One other difference between pre- and post-detector filtering is that in the latter case the bandwidth of the receiver as presented to the AGC circuit is wider than the overall bandwidth. This means, for example, that if you are selecting one CW signal from the receiver's output using a narrow audio filter, another stronger signal inside the receiver's i-f passband could cause the apparent strength of the desired signal to vary due to AGC action. The effect causes no particular problem, however, since even when it does occur it sounds very similar to fading caused by normal propagation effects.



The Datong Model FL1 audio filter, as well as being a variable CW filter with noninteracting center frequency and bandwidth controls, can also automatically locate, track and notch out single interfering heterodynes. It continually searches from 300 to 3000 Hz and needs only about two seconds to achieve lock. Notch bandwidth in the AUTO mode can be only 20 Hz. The notch is therefore inaudible while searching.



Datong's Model FL2 contains three linearly voltage-tuned filters: a five-pole elliptic function lowpass, a similar highpass, and a two-pole peak or notch. The three filters can be tuned independently with separate knobs, or ganged to simulate a bandpass filter with independent center frequency and bandwidth controls. Precise tracking by all twelve poles of filtering is achieved by using pulse-width modulation techniques to simulate twelve identical voltage-controlled resistors.

a new audio filter design for communications receivers

We have discussed the basic filtering requirements for communications receivers and have established that conventional SSB crystal filters by no means represent the last word in performance capability. We have also established that extra selectivity can be conveniently and effectively added to a receiver in its audio output circuit.

We now discuss a new audio filter design, Model FL2, which has recently been introduced by Datong Electronics Limited specifically to improve existing communications receivers in the ways already outlined. Model FL2 contains three quite complex and independent active audio filters. Each is tuned by a control voltage, and the linear frequency versus voltage curves are accurately matched to allow ganged operation. The filters comprise:

1. A five-pole elliptic-function lowpass filter.

2. A five-pole elliptic-function highpass filter.

3. A two-pole filter with independent peak and notch (that is, band-pass and band reject) outputs.

Five pushbutton switches select any of the various operating modes previously discussed. The switches connect the three filters in the correct combinations and also determine how the three filter control voltages are to be derived from the three panel controls.

Each filter is built from state-variable multiple op amp subsections using 1 percent metal-film resistors and polystyrene capacitors. Such filters have excellent immunity to variations in the active elements. This, and the precision passive components, give good tracking capability and long-term stability. A total of twenty-two op amps are involved in the filter sections, and an additional six op amps are involved in the control functions.

The nominal over-all gain of the filter is unity, and a 2-watt audio power stage is included. This means that the complete filter can be easily installed between the loudspeaker and audio output stage of existing receivers. Altogether, the system uses twenty-one integrated circuits, most of which contain multiple functions.

performance details

The five-pole elliptic-function low and highpass filters were designed to have a minimum stop-band rejection of 40 dB. Each filter has two frequencies of infinite attenuation in the stop-band. If the filter cutoff frequency (that is, the -1 dB point) is given by fC, then for the lowpass filter the infinite attenuation frequencies are at $1.29\,fC$ and $1.85\,fC$; and for the highpass filter they are at $0.55\,fC$ and $0.78\,fC$. Similarly the -40 dB points on the filter responses are reached at $1.25\,fC$ for the lowpass and $0.8\,fC$ for the highpass.

These filter responses are illustrated in **fig. 2A**, which shows the calculated response for high and lowpass filters in cascade, with cutoff frequencies at 500 Hz and 2500 Hz respectively. In both cases it is clear how the closeness of the first null response to the cutoff frequency gives a high rate of cutoff.

At a cutoff frequency of 2 kHz, for example, the rate of cutoff is 40 dB in 500 Hz for the lowpass filter. Similarly, if the highpass filter is set to a cutoff frequency of 500 Hz, the rate of cutoff below 500 Hz is 40 dB in only 100 Hz. For comparison, commercial SSB crystal filters tailored to good-quality Amateur-band communications receivers have typical rates of cutoff of 40 dB in 600 Hz. Model FL2 therefore has an appreciably sharper cutoff than typical SSB crystal filters.

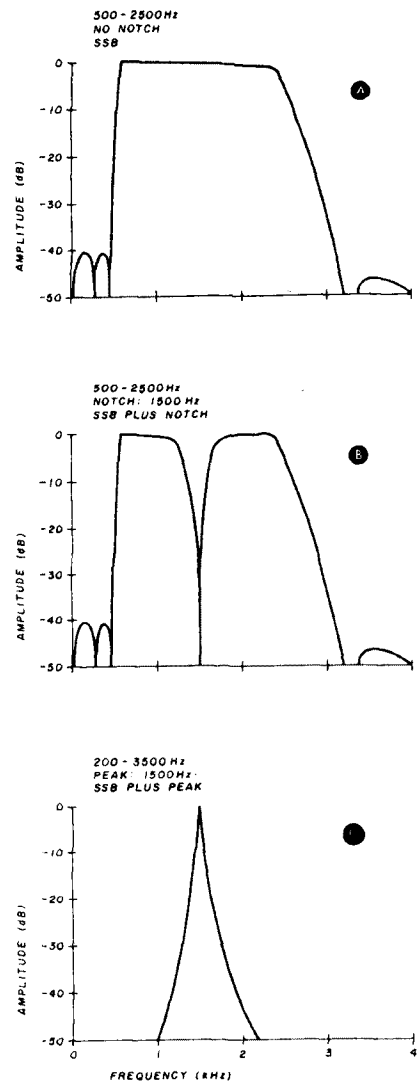


fig. 2. Theoretical response curves for Model FL2. These curves (and those in *figs. 3, 4,* and *5*) were obtained by using an HP-85 computer to solve the complete transfer function for Model FL2. Actual production units give very similar results. This is demonstrated, for example, by the actual response curves measured by Gunter Schwarzbeck and published in his independent and very detailed test report in *CQDL* (see reference 2). All three graphs have the lowpass filter set to 2500 Hz and the highpass to 500 Hz. A shows the response in SSB mode, B shows response in SSB + NOTCH mode with notch set to 1500 Hz, and C shows response in SSB + PEAK mode with same knob settings.

application to SSB reception

When the **SSB** button is pressed, the high and low-pass filters are connected into the circuit and their cutoff frequencies are independently controlled by the center and right-hand knobs respectively (photo). The tuning range for each filter is 200 to 3500 Hz, so that any desired bandpass characteristic can be obtained with the same general shape as that of **fig. 2A.**

When the **SSB + NOTCH** button is pressed, the high and lowpass filters behave in the same way; but in addition, the notch filter is connected in series and can itself be independently tuned by the left-hand knob over the same range of 200 to 3500 Hz. The notch width is fixed at 200 Hz at the −6 dB point and remains constant as the notch frequency is varied. An example of this mode is shown in **fig. 2B**.

Tuning a notch to a weak heterodyne can be difficult, and in such cases **SSB + PEAK** can be selected. In this mode, the peak output from the notch/peak filter is selected, and the filter can then easily be tuned onto the unwanted whistle. The 6-dB bandwidth in this mode is 200 Hz. After tuning onto the whistle, **SSB + NOTCH** would be reselected. The **SSB + PEAK** response corresponding to **fig. 3B** is shown in **fig. 2C**.

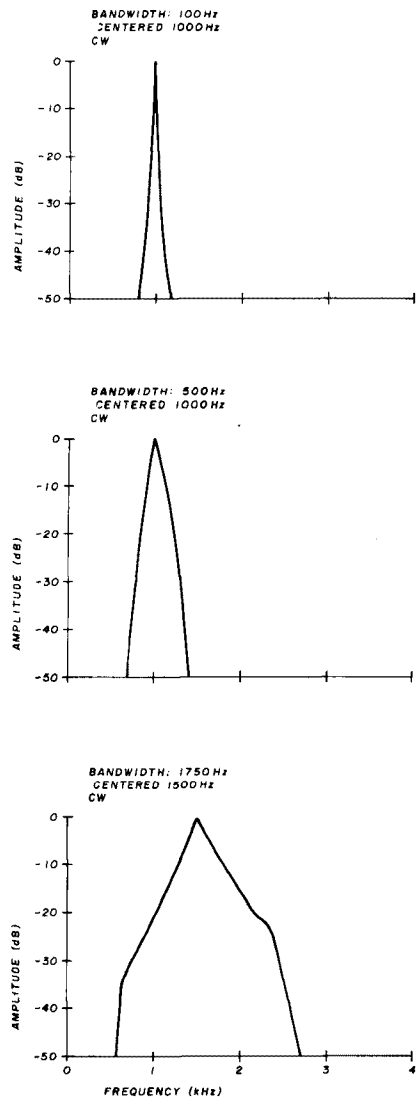


fig. 3. Three examples of the response in the CW mode. In this mode the response is a superimposition of two curves, one as in *fig. 2A* and the other as in *fig. 2C*. Note the center response and extremely good skirt rejection.

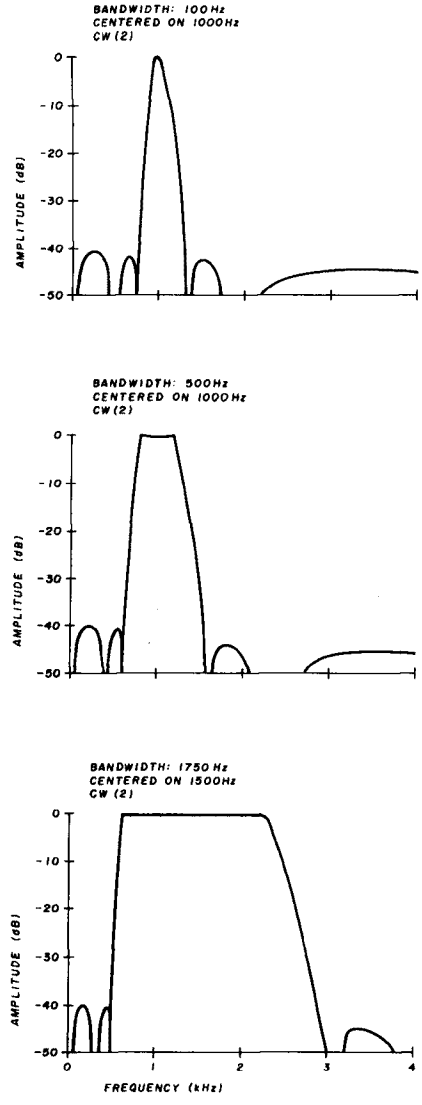


fig. 4. Three examples of the response in the CW(2) mode. The control settings correspond to those in *fig. 3*; and, in fact, the responses in *fig. 3* are those of *fig. 4* combined with the response of a two-pole peaking filter (as in *fig. 2C*). Note the relatively square passband. These curves are also typical of those obtainable in the SSB mode (but of course using different knob settings). Note also the two-notch stop-band responses characteristic of the five-pole elliptic function filters.

The SSB mode would also normally be the correct choice for a-m and fm reception and possibly also for SSTV. It could, of course, also be used for any other mode such as CW and RTTY, but a more convenient tuning method is provided for these modes as described in the next section.

application to CW and RTTY reception

Two CW modes are provided. They differ primarily in the shape of the response curves. Common to the two CW modes is that the high and lowpass cutoff frequencies are controlled by analog circuitry to simulate a composite bandpass filter whose center frequency and bandwidth are independently controllable. In these modes the center knob controls the center frequency from 200 to 3500 Hz, and the right-hand knob controls the bandwidth from 100 to 1750 Hz. As the center frequency is varied, the bandwidth remains constant; and similarly, the center frequency is independent of the bandwidth (subject always to the condition that the lower cutoff frequency can never go lower than 200 Hz and the upper cutoff frequency cannot exceed 3500 Hz).

To prevent confusion in panel markings, those which apply only to tuning of the type just described are printed in yellow, while those referring to SSB-type tuning or to both are in white.

The main CW mode is selected by pressing the **CW** *button. This connects the two-pole peaking* filter in series with the high and lowpass filters. The bandwidth of the peaking filter is ganged with the separation between the high and lowpass cutoff frequencies, and both are controlled by the bandwidth control (right-hand knob).

Composite response curves are illustrated in **fig. 3,** which shows the overall responses at skirt bandwidths of 100, 500, and 1750 Hz. In all cases a domed center response is combined with extremely good far-out stop-band rejection. The domed center response makes it easy to tune a CW signal to the center of the filter passband, since one merely tunes for maximum signal. The bandwidth can then be widened or narrowed symmetrically about the signal as desired without the need to retune. The 6-dB bandwidth varies from 70-700 Hz as the skirt bandwidth moves between its extreme values of 100 and 1750 Hz.

This passband shape is considered optimum for most CW reception, but an alternative, CW(2), is provided by simultaneously pressing the two buttons **CW** and **SSB**. The high and low filters are then controlled as in CW, but the peaking filter is disconnected. The result is a rectangular response shape exactly as obtained in the SSB mode; but since it is a "yellow" mode, the filters are still controlled by the center frequency and bandwidth controls. This effect is shown in **fig. 4** for the same control settings as for the CW curves. The CW(2) mode is especially suitable for use with CW nets or for RTTY reception.

A third "yellow"-mode RTTY is obtained by pressing both **CW** and **SSB** + **NOTCH** buttons. Here the filters are controlled in the same way as for the CW mode, but the two-pole filter is now used as a notch filter, and the notch width is ganged with the bandwidth function. The result is the passband shape shown in **fig. 5**. This is suitable for wide-deviation

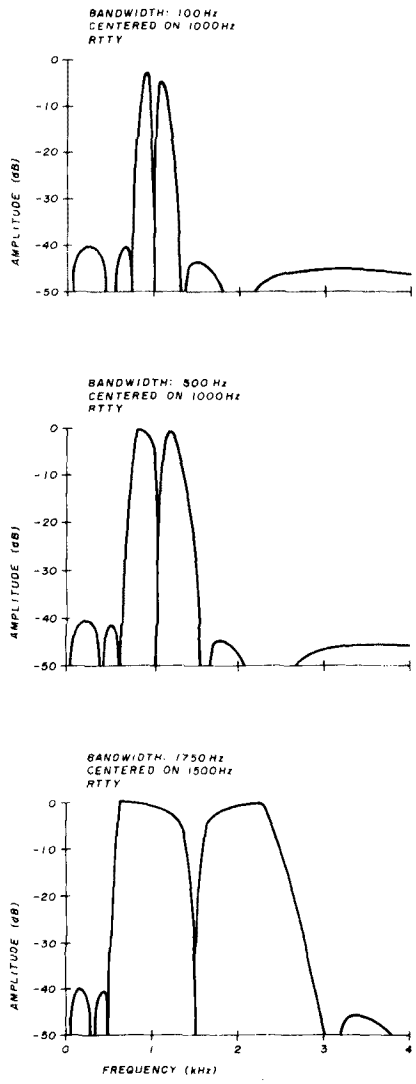


fig. 5. Responses obtained by selecting the RTTY mode but with the same knob settings as in *fig. 4*. The center notch width varies in sympathy with the overall bandwidth setting.

RTTY signals — the central notch giving increased immunity to interference.

other features

When using Model FL2 it is interesting to be able to determine the improvement due to the filter by comparing the signal before and after filtering. Once a desired filter mode is selected, by simultaneously pressing the two buttons **SSB + PEAK** and **SSB**, only the high and lowpass filters are left in circuit, and their cutoff frequencies are held at their lower and upper limits respectively. In other words, the bandwidth is expanded to maximum, and the effect is virtually equivalent to no filtering when used with normal communications receivers. Alternatively, when the **OFF** button is pressed the input signal is connected straight through to the output terminal, and power is removed from the filter. Since the overall gain is unity, no changes to volume level will be required.

A front panel headphone jack is included on the FL2; the loudspeaker output terminal is disconnected when phones are used. A second output connector is also included to allow a tape-recorder connection.

closing remarks

It is traditional that most passband shaping in communications receivers be carried out by the i-f filter. However, now that virtually all communications receivers feature good basic selectivity, effective AGC, and linear product detectors, it makes good sense to perform final bandwidth shaping in the receiver's audio section. Model FL2 was designed to take full advantage of this situation and offers a versatility of performance that would be very difficult to achieve at i-f. Yet, since it is an audio filter, it can be retrofitted to any existing receiver without any internal connections required.

Compared with previous audio filters, Model FL2 gives far sharper cutoff for SSB and better skirt selectivity for CW. This results from the comparatively large number of filter sections — twelve — all of which track precisely together to maintain the desired elliptic function response. Previous filters approaching this level of complexity have not been freely tunable, while previous tunable filters have been restricted to only relatively few sections.

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1. D.A. Tong, G4GMQ, "Audio Filters as an Aid to Reception — With Special Reference to the Datong Frequency-Agile Audio Filter Model FL1," *Radio Communication*, February, 1978, pages 114-118.
2. Gunter Schwarzbeck, DL1BU, "Testbericht: NF — Filter Datong FL2," *CQDL*, February, 1981, pages 56-59.

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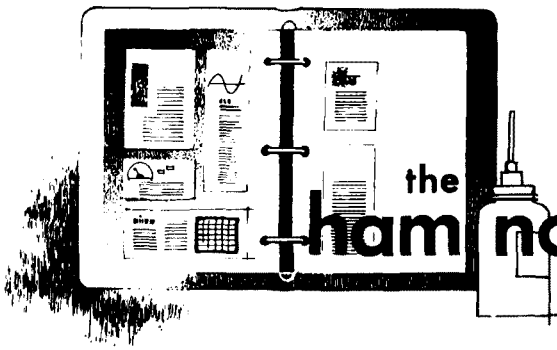
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interesting preamplifier for 144 MHz

What's so interesting about this 2-meter preamp? It doesn't have the lowest noise figure of any of the 2-meter preamps I've tested. It doesn't have the highest gain, although it has more than enough gain for any practical application. And it doesn't have the sharpest bandpass characteristic, although it's better than many other low-noise preamplifiers.

The interesting feature of this preamp is that it combines low noise figure, reasonable gain, and good bandpass characteristics with *low cost*. The NE73437 bipolar transistor (Q1, **fig. 1**) sells for only $1.75 (in 1-9 quantities), and the entire preamp can be built for under $10.

performance

The schematic is shown in **fig. 1**; the layout in **fig. 2**. Specifications, when tuned for *minimum noise figure*, are:

1. Noise figure, 1.0 dB.

2. Forward gain, 22 dB.

3. Reverse gain, 40 dB, with a gain margin (reverse gain minus forward gain, a measure of stability) of 18 dB.

The gain response (bandwidth) is shown in **fig. 3**. Note the expanded plot showing the region between 140 and 150 MHz. Overload and intermodulation characteristics are shown in **fig. 4**.

My experience has been that the first stage of a receiver is almost never overloaded (except in very special and rare situations, which most

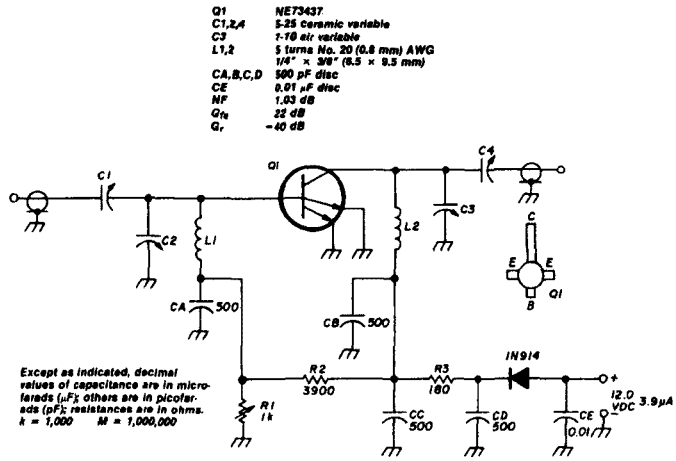


fig. 1. Schematic diagram of preamplifier.

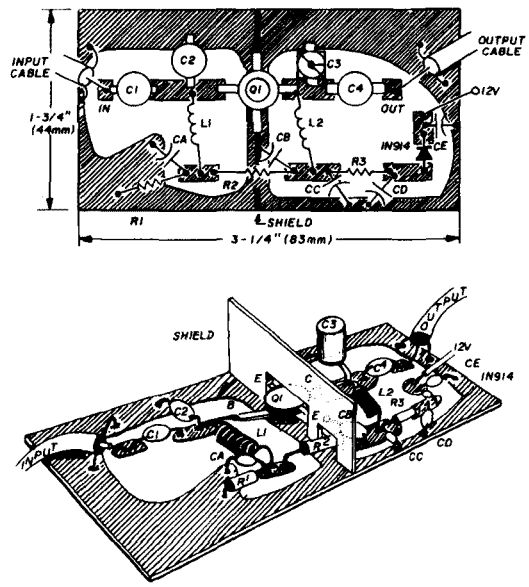


fig. 2. PC board and component layout. Note that the NE73437 device package has three equal-length leads and a longer (collector) lead. The base lead is opposite the collector lead.

of us never have to worry about), and that a −1 dB point, P_{-1}, of −20 dBm of input power, with a third-order intercept point at I_3 of 18 dBm is, at least, adequate for most stations. The gain and noise figure of this preamplifier are good enough for all but moonbounce work, in which situation this unit makes an excellent second stage. You can use several feet of coaxial cable between first and second stages, and at least 100 feet of RG-8/U between this preamp as a second stage and a receiving converter without concern over insufficient gain or second-stage degradation of system noise.

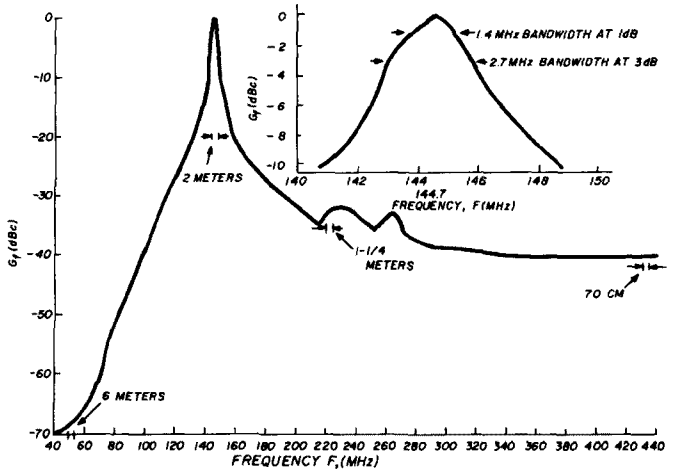


fig. 3. Preamplifier frequency response.

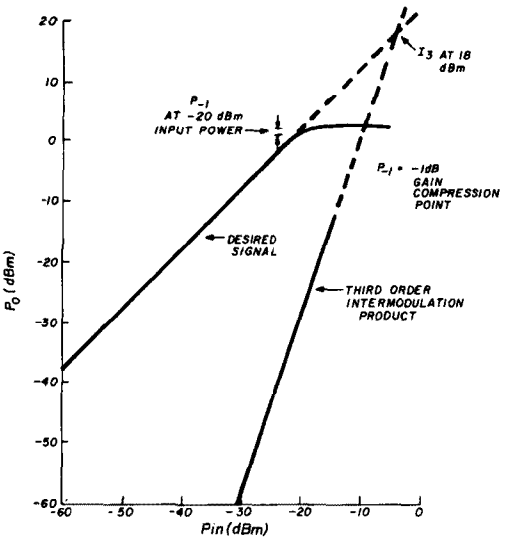


fig. 4. NE73437 preamplifier input/output and intermodulation response.

construction

A single-sided PC board layout is shown in **fig. 2**. Use good vhf wiring practices (short leads) and make sure a shield is used as shown; a shield box should also be used around the unit.

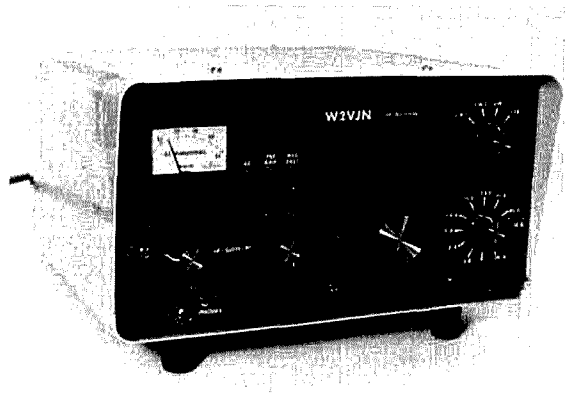
The NE73437 is built in a plastic package, having a collector lead longer than the pair of emitter leads to either side of it, or the base lead opposite it. Make sure to solder both of the emitter leads to ground and to place the shield over the emitter leads, but only after soldering the rest of the components in place. No other special precautions were found to be necessary.

tune up

Connect a 12 Vdc source to the preamp and set the bias pot (R1) for a total preamp current of about 4 mA. Adjust C1,C2,C3 and C4, in any order, for maximum gain. If you have access to a noise generator setup, tweak C1 and C2 for lowest noise figure. The weak-signal reception method can also be used to tweak for best noise figure. The preamp can be modified for use at 220 and 432 MHz.

The device is available from California Eastern Labs, 3005 Democracy Way, Santa Clara, California 95050 (CEL supplied much appreciated data and samples for the prototype of this preamplifier). I will answer all questions upon receipt of a self-addressed, stamped envelope.

Geoffrey H. Krauss, WA2GFP



up-conversion receiver for the high-frequency bands: part one

Build it — try it out. Does it set a new standard for performance? You be the judge

author's note
The object of this two-part construction project is strictly educational. I wanted to see if it was possible to produce a fairly good unit with readily available parts and, if so, to go on to design and construct a transceiver. Because of this, the module construction was done in breadboard fashion. There are no board layouts available, but some of the photos show typical construction techniques used throughout.

After a ten-year hiatus of little Amateur Radio activity, my S-line equipment started to look old when compared with the transceiver ads in the magazines. Surely, radios that looked this good must outperform my 20-year-old units. But which one to buy? With a well-equipped lab at my disposal, I decided to check out some available units. The results were generally disappointing, in my opinion. Except for third-order intermod performance, my old box full of tubes ran rings around the new solid-state units.

One of the new units I checked out had a strong front end but lacked sensitivity, very poor AGC characteristics, and produced a lot of hum and noise if an external audio filter wasn't used.

Another unit had excellent sensitivity, adequate overload characteristics, and good AGC; but synthesizer phase noise was excessive.

A third unit had an excellent operating "feel" and sound for DXing and contesting but had a soft front end.

A fourth unit wasn't considered for testing because of its poor reliability, as reported by a number of owners. Little testing was performed on the transmitters, although two of the units had key clicks and one had a slight chirp on CW; also its ALC characteristic was poor.

The digital readout and no-tuning features sold me on the solid-state rigs, but I couldn't decide on which compromise to make. So I constructed this receiver as a breadboard project to see if a full-blown transceiver effort was feasible. By constructing this receiver, I could concentrate on the *basic performance* characteristics and leave the frills for later, or leave them out completely.

design

The basic configuration is shown in **fig. 1**. Up conversion eliminates the need for tunable filters at the front end. With this conversion method, adequate image rejection can be obtained with a simple low-

By George Cutsogeorge, W2VJN, Plasma Physics Laboratory, Princeton University, P.O. Box 451, Princeton, New Jersey 08544

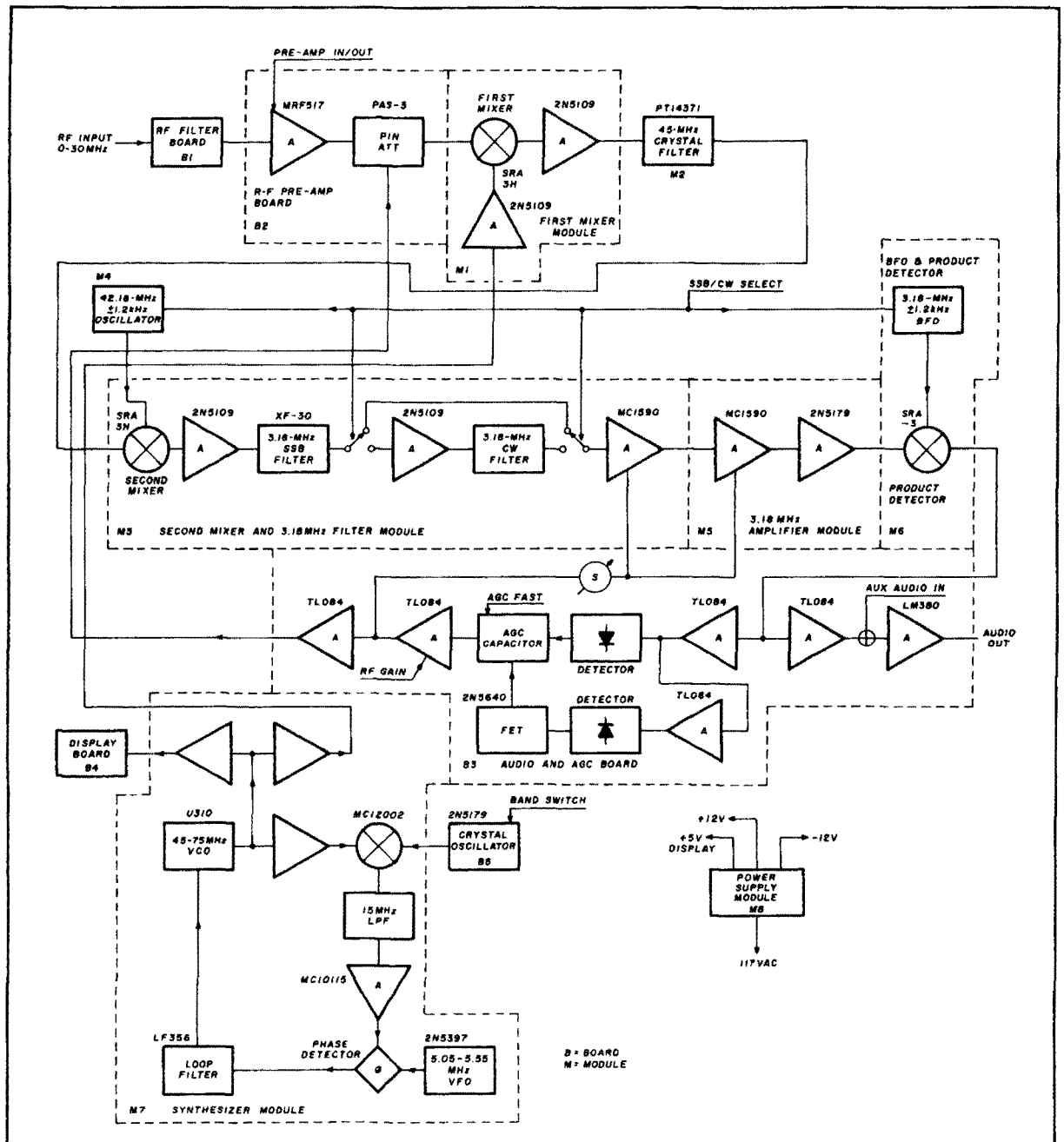


fig. 1. Block diagram of the up-conversion receiver. Breadboard construction techniques were used to allow changes in circuitry as the design developed.

pass filter. The input filters are followed by an rf stage. This stage may be switched in when high sensitivity is required, or it may be switched out when maximum resistance to overload is needed. The high sensitivity is useful on a quiet 10-meter band or when an inefficient antenna is used.

An electronically variable attenuator between the rf amplifier and first mixer reduces the signal level for high-amplitude signals. The first mixer uses 17-dBm injection and provides a third-order intercept of 25 dBm. The first i-f is at 45 MHz. A small amount of gain is inserted to maintain an adequate front-end noise figure.

A monolythic crystal filter at 45 MHz protects the

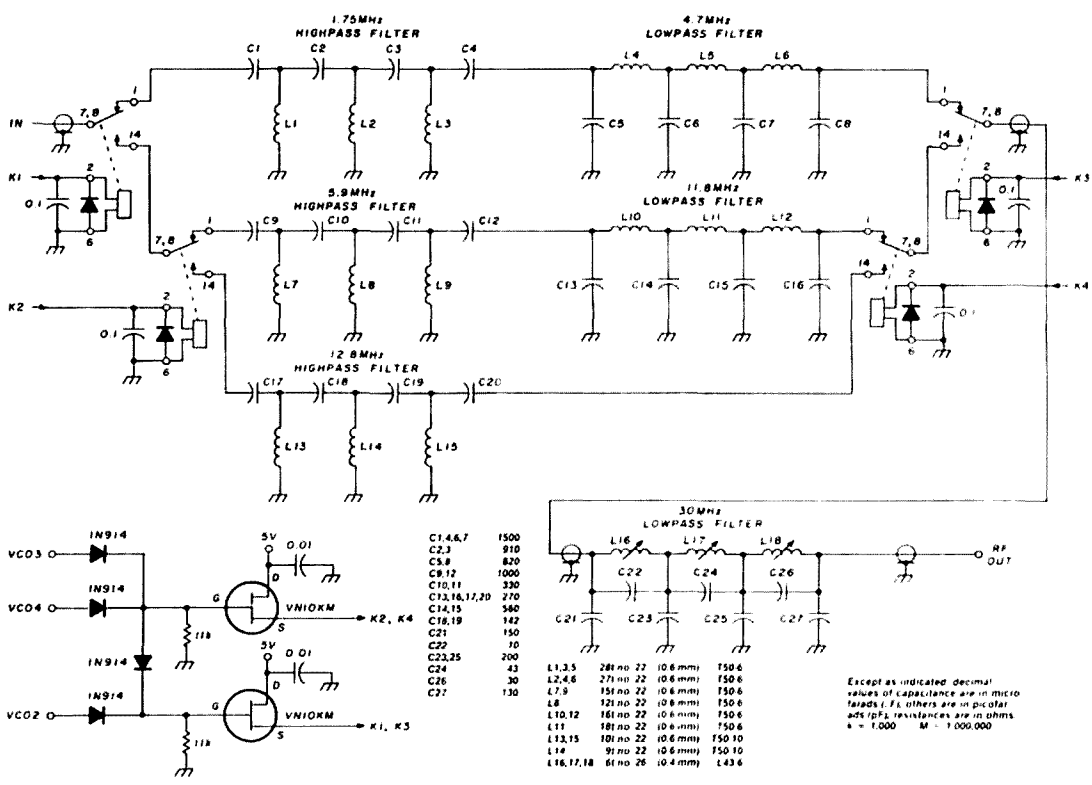


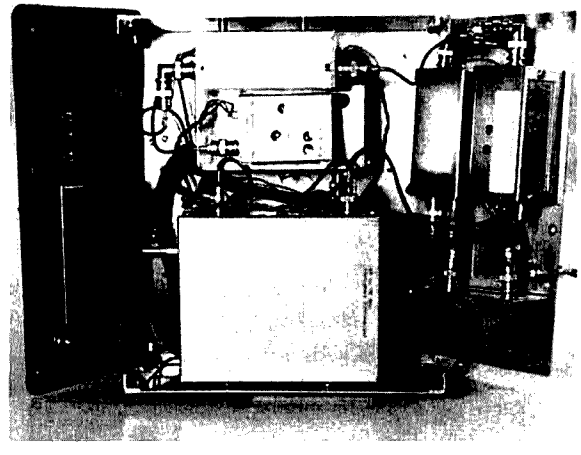
fig. 2. Rf-filter schematic (B1 board). Reed relays, which select the front-end filters, are controlled by the band switch.

second mixer from out-of-band signals. If good SSB and CW filters were available for 45 MHz, a second mixer wouldn't be necessary. This is not the case, however, so the main receiver selectivity is obtained at 3.18 MHz in the second i-f. The second mixer is also a high-level mixer and is driven at 13 dBm. Crystal filters are readily available for many different bandwidths at 3.18 MHz. A pair of MC1590s provide more than enough i-f gain and AGC range.

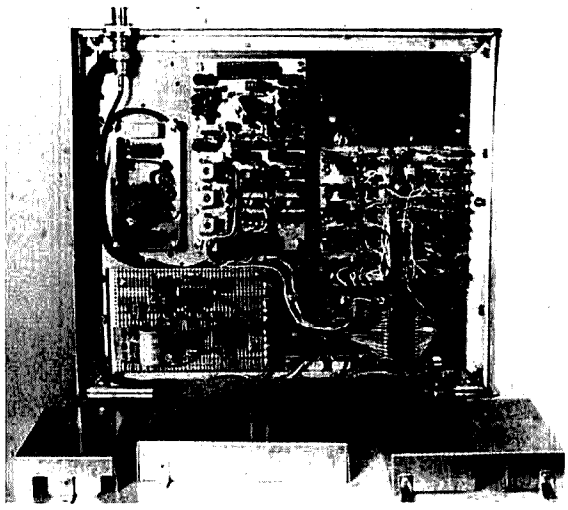
A 7-dBm drive-level, double-balanced mixer is used for the product detector. An audio amplifier completes the signal-path circuit. AGC voltage is derived from the audio signal and controls the second i-f amplifier gain and the front-end attenuator. A hang-type circuit is used.

Main receiver tuning is accomplished with a 5-MHz VFO. A 45- to 75-MHz VCO is phase-locked to the VFO in one-half megahertz bands. The VFO is heterodyned with a crystal oscillator operating 5.05 MHz below the minimum injection frequency required for the selected band.

For example, to cover the 7.0- to 7.5-MHz band the injection frequency must be 45.0 MHz higher, or 52.0 to 52.5 MHz. The crystal frequency required



Top View of receiver removed from its cabinet. The front and rear panels may be swung away from the main assembly for maintenance. Most modules above the deck are built in miniboxes. The large box houses the VFO, VCO, and phase detector board. On the left is the front panel showing the display module and the various controls. On the right is the rear panel holding the 45-MHz crystal filter, the first mixer and the BFO modules. At the top center are the second mixer, 48.18-MHz oscillator and 3.18-MHz amplifier modules.



Bottom view of receiver with shields removed. Small board in the upper left is the rf preamplifier. To its right is the filter board. On the right side is the crystal-oscillator board, and in the lower left is the audio-AGC board. All except the audio board are normally covered with aluminum shield boxes.

would be 46.95 MHz. The second-mixer injection is provided by a 48.12-MHz crystal-oscillator signal. Switching is incorporated to move the frequency to either 1.2 kHz or − 1.2 kHz for upper- or lower-sideband selection. The BFO provides 3.18 MHz ± 1.2 kHz for the product detector, and the switching is ganged with the 48.12-MHz crystal oscillator. A digital counter that subtracts 450,000 from the measured frequency monitors the VCO and provides a digital readout. The display may also be used externally as a test frequency counter.

table 1. Measured performance characteristics of the up-conversion receiver.

	frequency or mode	preamp out	preamp in
noise floor	SSB	− 128 dBm	− 132 dBm
	CW	− 133	− 141
blocking, CW:	2 kHz	148	146
desired signal − 70 dBm;	20 kHz	151	148
dB above noise floor	100 kHz	151	148
two-tone intermod, CW:			
second-order intercept		50 dBm	
third order intercept	10 kHz	− 1 dBm	− 12 dBm
	100 kHz	17 dBm	4.5 dBm
phase-noise degradation	3 kHz	2 dB	
of noise floor for	10 kHz	2 dB	
100 dB signal	20 kHz	3 dB	
	100 kHz	2 dB	
	250 kHz	0 dB	
image rejection		85 dB	
first i-f rejection		88 dB	
second i-f rejection		> 100 dB	
AGC threshold		2.8 μV	0.3 μV

performance characteristics

Table 1 shows the receiver's measured performance. Noise-floor measurements indicate a noise figure of 8 dB with the preamplifier in. While this is adequate for normal high-frequency operation, it could be reduced by minimizing the losses ahead of the first mixer.

The blocking performance is very good, and a rather large desired signal level was used to eliminate the effects of phase noise on the measurement. The third-order intercept was measured at two-tone spreads to show the effect of the 45-MHz crystal filter. The second-order intercept varies, depending on the front-end filter attenuation, but the number shown is typical.

The receiver's phase-noise degradation is substantially less than that of other modern synthesized receivers I tested. This is due to this receiver's wide loop bandwidth in the synthesizer and the high-Q components in the 5-MHz VFO.

Image and i-f rejection are quite good although not as high as the filter alone should provide. Better shielding of the front-end modules and the use of miniature hardline to couple them would bring the rejection to greater than 100 dB.

front end

Front-end filters minimize out-of-band interference. See **fig. 2**. A 30-MHz Cauer lowpass filter is in line at all times. It is designed to provide 80-dB image rejection by itself and has a notch at the first i-f of 45 MHz.

A highpass, lowpass filter combination is switched in for frequencies below 1.75 and 4.7 MHz. This filter has 0.5-dB attenuation from 1.8 to 4.5 MHz and is down 50 dB below 1.1 MHz and above 7.4 MHz. A



Typical board construction as shown on the filter board. Terminal strips are soldered to PC material directly. Components are supported on strips and groundplane. Breadboard rf circuitry may be constructed rapidly with this technique.

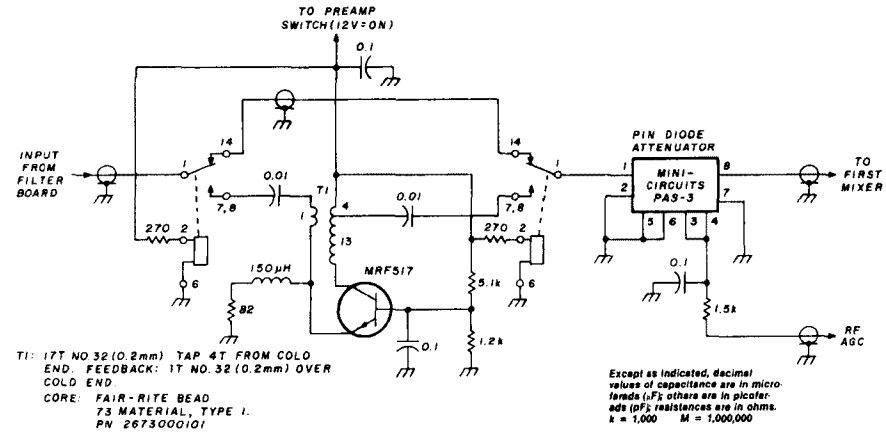


fig. 3. Rf pre-amplifier schematic (B2 board). Circuit uses transformer-coupled negative feedback and has a gain of 10 dB.

second set of highpass, lowpass filters covers 5.9 MHz to 11.8 MHz with 0.6-dB attenuation from 6.5 MHz to 11 MHz. This set is more than 50 dB down below 2.5 MHz and above 21 MHz. Finally, a highpass filter is used for frequencies above 12.8 MHz. The filter has less than 0.4-dB attenuation above 14 MHz and more than 50 dB below 7.5 MHz.

These filters are constructed on double-sided copper-clad board using Amidon coil forms. Reed relays are used to select filters and are controlled by the band switch. Relay drivers are VN10KM FETs (**fig. 2**).

The MRF517 amplifier, **fig. 3**, uses transformer-coupled negative feedback. It has a gain of 10 dB and is flat beyond 100 MHz. Reed relays switch the amplifier in and out.

AGC is applied with a Mini-Circuits PAS-3 PIN diode attenuator following the rf amplifier. This unit is not activated unless the signal level exceeds a threshold set on the audio-AGC board. It is adjusted to start attenuating if the input signal exceeds 100 µV. This attenuation reduces the signal level in the stages ahead of the 3.18-MHz i-f filters.

first mixer

The first-mixer-module schematic is shown in **fig. 4**. It contains a Mini-Circuits SRA3H mixer and two 2N5109 feedback amplifiers. One is used as an i-f post amplifier, and the other increases the synthesizer injection signal to 17 dBm. These 2N5109 amplifiers operate at 55 mA collector current. Clip-on heatsinks keep the transistor operating temperature down. Amplifier gain is about 14 dB, and the output compression point is 23 dBm. Input and output impedances are approximately 50 ohms. Frequency response is very flat, being down about 0.5 dB at 110 MHz, the upper limit of my test equipment. Third-order intercept measurements on this module indicate a level of 24 dBm. This is to be expected for this mixer amplifier combination. No degradation is apparent when the 45-MHz crystal filter is introduced. I had some concern that the feedback amplifier would

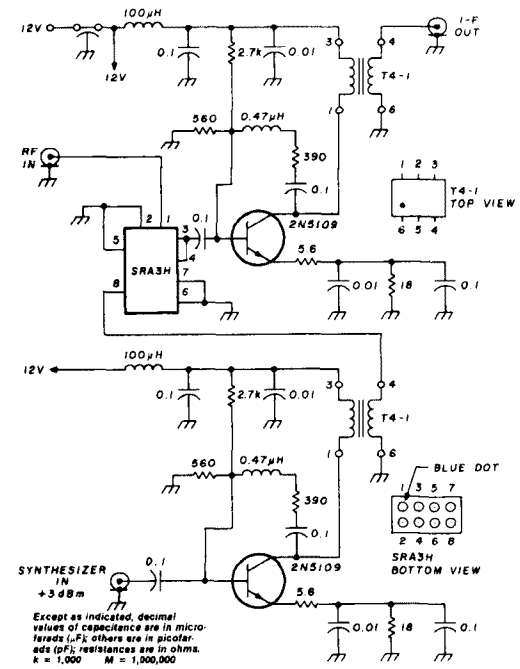


fig. 4. First-mixer schematic (M1 module). One of the 2N5109 feedback amplifiers is used as an i-f post amplifier, and the other increases the synthesizer injection signal to 17 dBm. Amplifier gain is about 14 dB; the output compression point is 23 dBm.

reflect an improper load for the mixer, out of the filter passband; however, the amplifier input impedance does not vary enough from 50 ohms to degrade the intercept point.

first i-f filter

The first i-f was placed at 45 MHz to enable the use of a standard Piezo Technology, Inc., monolithic filter. Their model 4371 is a four-pole unit in an HC-18 case. It has an advertised 3-dB bandwidth of 15 kHz with 1-dB ripple in the passband and a 3-dB loss. Aside from some sharp spurious responses, its ultimate rejection exceeds 50 dB. This filter has 7000-ohm input and output impedances, so networks are required to make it usable. See **fig. 5**. Considerable experimenting showed that achieving low insertion loss and good ultimate rejection at 45 MHz is not easy.

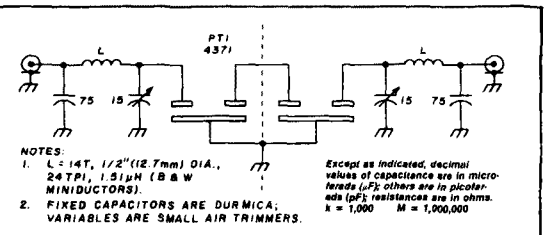


fig. 5. 45-MHz filter schematic (M2 module). The first i-f filter uses a standard Piezo Technology, Inc., monolithic 4-pole unit in an HC-18 case. The 3-dB bandwidth is 15 kHz with 1-dB ripple in the passband and a 3-dB loss.

The insertion loss is important to minimize the receiver noise figure while maintaining large signal capabilities. If the filter loss is excessive, the gain preceding the filter must be high enough to give a good noise figure, but that would reduce the large signal-handling capabilities of the receiver.

Pi matching networks were used at the filter input and output. Coils and capacitors of very high Q must be used to minimize insertion loss. B&W miniductors were used with small air trimmers and Dur Mica capacitors. Over-all loss, input to output, was held to

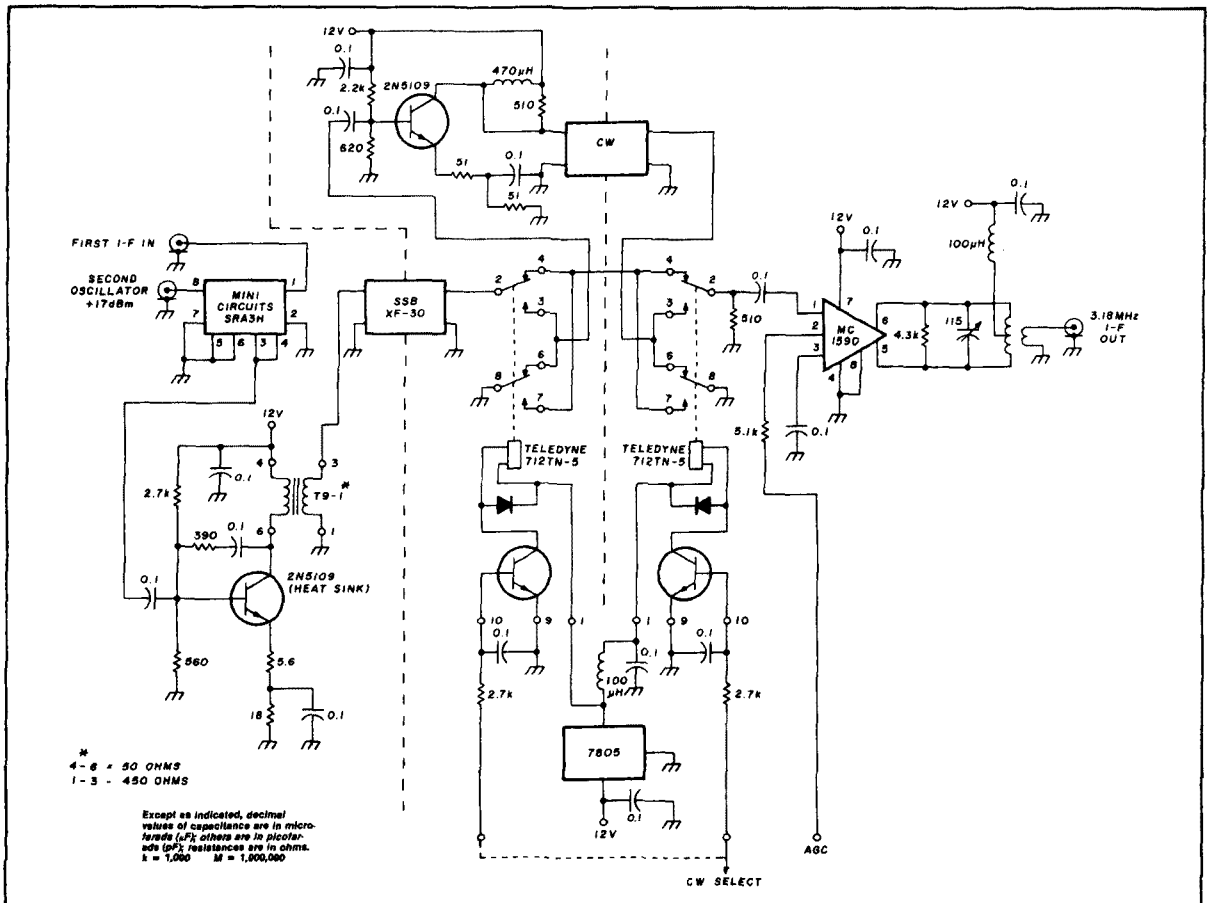
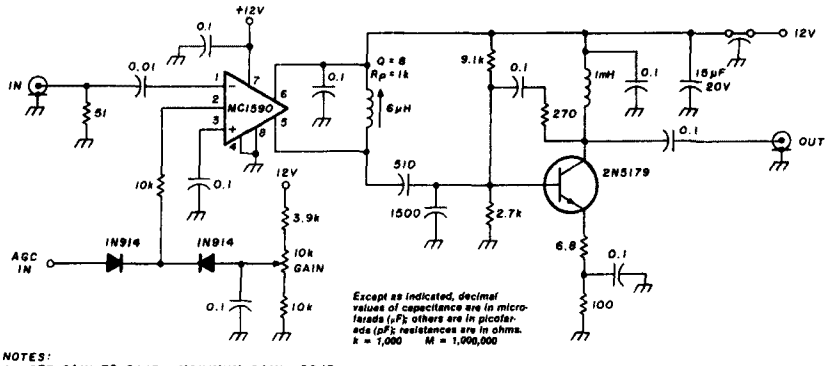


fig. 6. Second mixer and 3.18-MHz crystal filter schematic (M3 module). This high-level unit preserves good high-amplitude performance for frequencies within the 45-MHz filter passband.



NOTES:
1. SET GAIN TO 26dB, MAXIMUM GAIN = 32dB.
2. MEASURED: WITH TWO TONES AT -30dBm, EACH IMD IS -55dB; THEREFORE $TOI = -4 + \frac{55}{2} = 22.5dB$ OUT. WITH OUTPUT AT -10dBm PER TONE, IMD > -65dB.

fig. 7. 3.18-MHz amplifier schematic (M5 module). A second MC1590 and a 2N5179 feedback amplifier complete the i-f chain. They are mounted in a separate module to hold down the over-all gain per module.

less than 2 dB by this method. To achieve good out-of-band rejection, it was necessary to mount the 4371 directly under a solid copper shield that separates the input and output circuits. After considerable adjustment of component position, ultimate rejection of 70 dB was obtained.

second mixer

To preserve the good high-amplitude signal performance for frequencies within the 45-MHz filter passband, a high-level unit was used as the second mixer. A 2N5109 feedback amplifier follows the mixer and is designed to provide a 500-ohm drive signal for the XF-30 SSB crystal filter. A subminiature relay selects SSB or CW. When CW is selected, a 300-Hz crystal filter and a gain-equalizing amplifier are inserted into the signal line. The equalizer gain is adjusted to offset the CW-filter loss. After filtering, an MC1590 provides more i-f gain and AGC voltage. Fig. 6 shows the schematic.

A second MC1590 and a 2N5179 feedback amplifier complete the i-f chain. They are mounted in a separate module to hold down the over-all gain-per-module. The schematic is shown in fig. 7. The maximum drive level to the product detector is held to −10 dBm by the AGC system. The MC1590 cannot drive the mixer directly while maintaining low two-tone intermodulation. The feedback amplifier can produce −10 dBm with very low distortion and allows the MC1590 to operate at less than −20 dBm. This combination has third-order IMD products that are greater than 65 dB down at an output level of −10 dBm per tone output. This amplifier is set to 26-dB gain but has a maximum of 32-dB gain available.

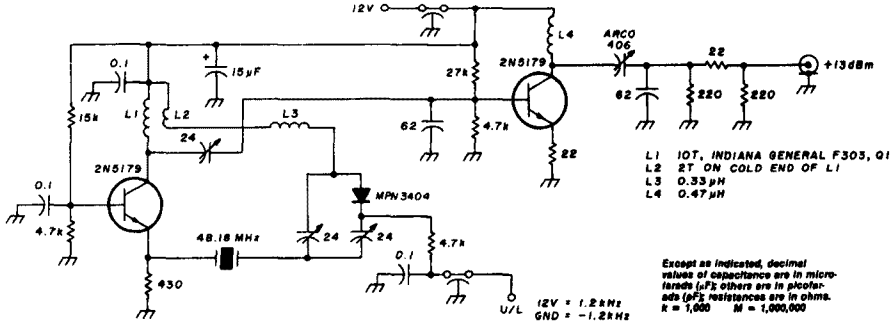


fig. 8. 48.18-MHz oscillator schematic (M4 module). Second-mixer injection is provided by this crystal oscillator. Output frequency may be shifted by a combination of a small capacitor and inductance in series with the crystal and by a second capacitor, which can be switched in with a PIN diode.

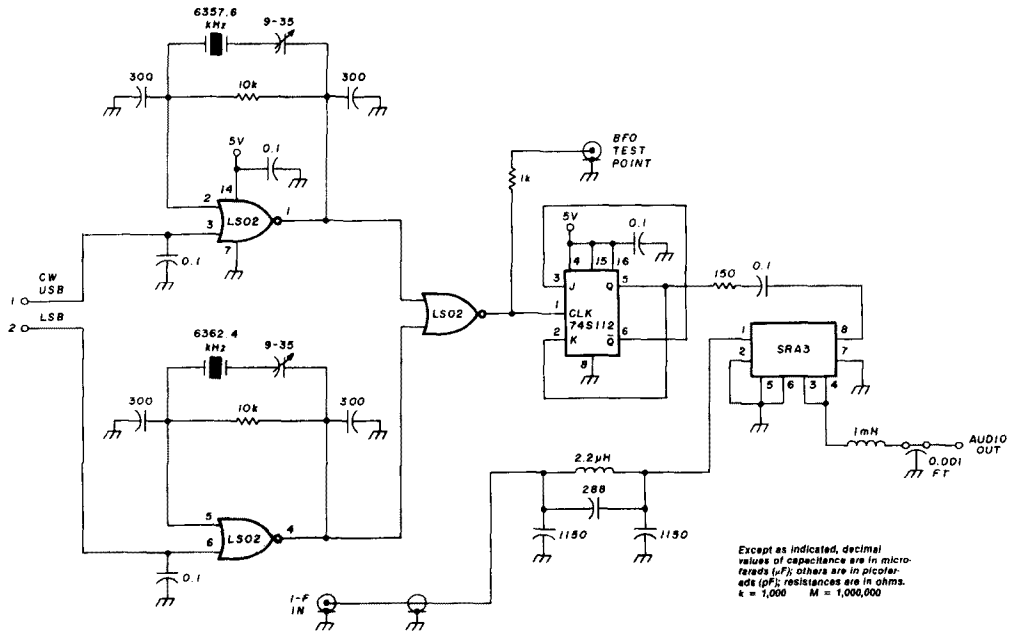


fig. 9. BFO and product-detector schematic (M6 module). **The BFO consists of two crystal oscillators, one for LSB and one for USB/CW. An SRA-3 double-balanced mixer is used as the product detector. Unit gives excellent results when driven with a square-wave carrier.**

second mixer injection

The second mixer injection is from a crystal oscillator operating at a nominal frequency of 48.18 MHz. See **fig. 8**. An offset equal to the BFO offset must be applied to this oscillator for USB/LSB selection to keep the signal frequency constant. By placing a small inductor and capacitor in series with the crystal the output frequency can be shifted 1.2 kHz. A second capacitor switched in with a PIN diode can then pull the frequency to 48,180-1.2 kHz. A buffer amplifier provides the power output to drive the second mixer.

BFO and product detector

An SRA-3 double-balanced mixer is used as the product detector. When driven with a square-wave carrier, this unit will give excellent results. For a −10 dBm input signal, the harmonic distortion is 44 dB down; with a −20-dBm input, the harmonics are better than 60 dB down. A Cauer filter is used on the i-f port to attenuate any harmonics generated in the i-f amplifier. If they are allowed into the product detector, they would be heterodyned to audio frequencies and create harmonic distortion.

The BFO consists of two crystal oscillators, as shown in **fig. 9**, one for LSB and one for USB/CW. Low-power Shottky two-input gates are used for the active elements. One input is biased into the linear region. The crystal is connected from gate output to input with a series frequency-adjusting capacitor. The two 300-pF mica capacitors complete the Colpitts configuration. The other gate input is used in the normal manner, to select the BFO frequency.

These oscillators run at twice the desired output rate so that a divider can be used to obtain a good square wave. A 74S112 flip-flop is used because of its small difference in propagation delay for positive- and negative-going edges. This unit drives the LO port on the SRA-3 through a dc blocking capacitor and a 150-ohm resistor. This is a simple but effective way to drive a mixer from a logic signal. A good square wave is necessary to minimize harmonic distortion. The third-order intercept of the mixer is increased somewhat by this technique.

Next month, in the second half of this two-part article, I will describe the construction of the audio and AGC board, the synthesizer, and power supply.

ham radio

owners' survey — TR7

A survey of owners' opinions of the Drake TR7

This month, the *ham radio* readers' survey deals with the popular Drake TR7, certainly one of the most desirable high-frequency transceivers in recent years. One hundred and ninety-five completed and usable questionnaires were returned by our readers.

The Drake TR7 is a synthesized transceiver that provides continuous receive coverage from 1.5 to 30 MHz, and transmits on all Amateur frequencies currently assigned within this range. The circuit combines a frequency synthesizer with a PTO, and there is a 1-kHz dial and 100-Hz digital readout resolution. The receiver has full passband tuning, with a first i-f of 48.05 MHz. The radio features solid-state, no tune-up operation.

the good features of the TR7 . . .

In response to the question, What is the rig's best feature?, the most frequent answer was the general coverage aspect of the radio. Thirty-six percent of the respondents mentioned this capability and the high quality of the TR7 receiver, which was praised for both its sensitivity and selectivity. (Note that, with the optional Range Program Board, the TR7 will tune 0 through 30 MHz, and programmable, out-of-band *transmit* capability is available for other frequencies such as MARS, Embassy, Government, and the new WARC bands.) Several Amateurs said how much they enjoy being able to use the TR7 for SWLing.

Thirty-one percent of the respondents mentioned the broadband characteristics of the radio as among its best features (many — in fact, most, respondents listed more than one "best feature.") Because the radio is solid-state, there is no need for preselection tuning or transmitter adjustments. Many of the respondents to the questionnaire who had been accustomed to operating only tube-type radios were appreciative of this aspect of the TR7.

Other "best features" frequently mentioned were ease of operation (16 percent), flexibility (9 percent), good audio (9 percent), portability (8 percent), and the digital readout (7 percent). Here are some representative replies to the question, What is the rig's best feature?:

"Flexibility — it does everything! A-m is clear, and accessories all plug in together and work well." — AKØU

"General coverage receiver, ease of operation, passband tuning." — WD8JUB

"Hard-hitting, pleasing, clean CW receive note; ease of alignment." — KL7T

"Continuous coverage from 0 to 30 MHz." — AG8T

"Receiver is excellent, especially filters and passband tuning. Good physical layout, and easy to manipulate the controls. I like the full frequency ability — I do SWLing. Most flexible receiver to use: it's a real pleasure!" — AE2J

"*The 0-30 MHz receiver. The receiver has excellent* sensitivity and dynamic range. I often get solid copy after other stations give up. The no-tune QSY feature of the transmitter is excellent. Also very rugged output. My transceiver was once key down (at reduced power) for 20 hours with no detectable change to either the TR7 or its power supply." — AF4B

"Digitally programmed frequency selection. The rig will never be obsolete." — WB6QDS

"Flexibility: the ability to use many modes of oper-

By Martin Hanft, WB1CHQ, Production Editor, *ham radio* magazine

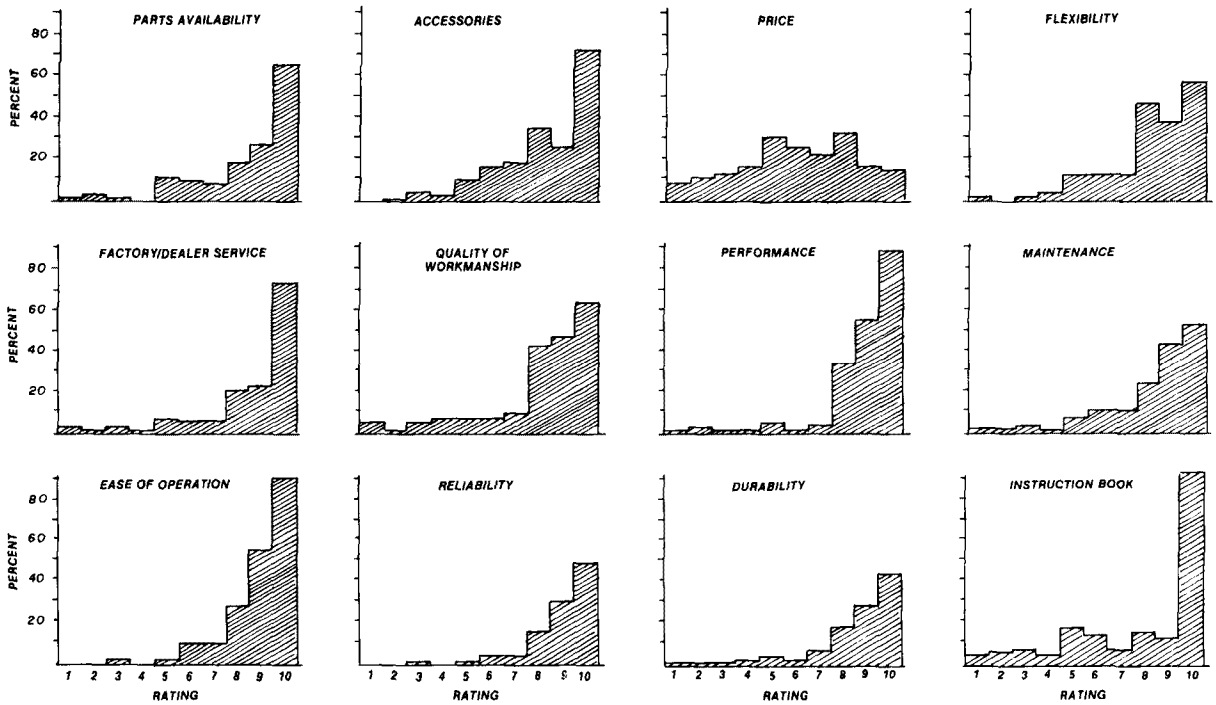


fig. 1. How the TR7 was rated, from 1 (poor) to 10 (perfect).

ation, wide frequency coverage, and the possibility of connecting many external components, such as receiver and linear amps, making the TR7 the central control point of the station."

"No tune-up. I use the passband tuning and the RIT often to get rid of QRM. I also use the STORE pushbutton for DX pileups." — N6XL

"Ease of operation. Transmit audio: Many stations comment that my audio is better than most and even more readable than others with the same signal strength." — W9KFQ

"Excellent receiver with passive front end and choice of receiver i-f filters. General coverage capability. Plug-in circuit boards. Ability to use digital display as frequency counter. Passband tuning. VOX controls on front of unit. Covers new bands and MARS." — W9UI

"Excellent skirt selectivity and dynamic range." — AA5O

"No tuning of output stages; RIT; built-in frequency meter; continuous coverage." — W4UI

"160-meter capability." — W6GAW

"Excellent receiver: Freedom from overload, IMD, and cross-modulation distortion. Flexibility: Can transmit and receive over whole hf spectrum; can also receive VLF." — N2MS

"Super receiver section. I have owned most of the popular rigs and I consider the TR7 the best transceiver available." — K3OX

"Good read-out, good passband tuning, and easy to work on or modify. Good general coverage performance; very stable; no warm-up or drift. Runs very cool with fan, which is very quiet." — W7UC

"It's hard to say which is best, it's got so many great features. Easy to operate; can be quickly disconnected from home station and put in car; great audio on transmit and receive. Easy to operate mobile: Very stable VFO on rough roads." — KA7AWS

table 1. Best feature. The percentage refers to the number of respondents who listed that feature as best. Note that many respondents listed more than one "best feature."

	percent
general coverage receiver	36
broadband qualities	31
ease of operation	16
good audio	9
flexibility	9
no tune-up	8
battery operation and portability	8
digital readout	7
stability	6
built-in frequency counter	6
clean CW	5
power output	4
good accessory connections	4

table 2. Worst feature. The percentage refers to the number of respondents who listed that feature as worst.

	percent
PTO drift	10
poor metering	9
auxiliary programming	7
service manual	6
front panel appearance	5
noisy receiver at minimum volume	5
size of pushbuttons	4
price	4
AGC always on	4
sensitivity to SWR	3

table 3. Problems. The percentage refers to the number of respondents who listed the problem on their survey form.

	percent
no problems	32
frequency drift	10
bad solder joints	6
PIN diode problems	6
tuning dial	5
bad transistor	4
rf in audio	2
low audio output	2
voltage regulator	1

table 4. Accessories. The percentage refers to the number of respondents who bought the accessory listed.

	percent
additional filters	31
remote VFO	18
fan	16
service manual	9
noise blanker	8
speech processor	8
external speaker	7
matching network	6
amplifier	4
wattmeter	4

table 5. Desirable additional features. The percentage refers to the number of respondents who would like to see the feature incorporated into the TR7.

	percent
notch filter	18
second VFO (now available as outboard accessory)	13
speech processor (now available as outboard accessory)	9
noise blanker (now available as accessory)	5
fixed sidetone volume adjust	5
phone patch jack	4
built-in power supply	4
fm mode	3
programmable memory	3
microcomputer interface	2

"Versatility — it works MARS on many out-of-band frequencies. The TR7's ability to reach anything from 1.5-30 MHz with no need for transmitter adjustments or receiver preselection makes it a great pleasure to operate." — WA4SHP

"Extremely accurate frequency readout — can operate with confidence, knowing I'm on frequency. Passband tuning operates just great! Comes in handy most of the time I'm operating. General coverage receiver adds to the enjoyment." — VE3LIQ

"Wide frequency range. The XYL enjoys SW broadcasts and I like to copy ship-to-shore CW on lf and hf. Very convenient for use in our travel trailer." — W8BH

. . . and the bad

In response to the question, What is the rig's worst feature?, the highest percentage of respondents, 10 percent, reported drift in the PTO. Nine percent complained about the metering on the rig — being not calibrated well or being ineffective — and about 7 percent did not like the STORE (frequency display) capability, finding no use for it. Other votes for the worst feature of the TR7 went to the service manual (for providing too little information), the looks of the front panel, the small size of the pushbuttons, and the price.

Here are some sample replies to the question, What is the rig's worst feature?:

"The lack of explanation in the owners' manual on the best ways to use the passband tuning feature. I still have not convinced myself that I am using it properly on SSB. The owners' manual should offer more technical information on the rig. I had to purchase the service manual in order to find out what's inside the rig." — AIØW

"Has small, slow, frequency drift during the first hour from a cold start. After that it is very stable." — W7FSP

"Click in phones when switching from CW to SSB." — K5AS

"Price. Doesn't have fm mode. Doesn't have notch filter. Doesn't come with mike or 12-volt power plug." — WD8PAQ

"Haven't found any! I really can't say anything bad about this rig." — WA2MNG

"No break-in. No possibility of switching the AGC off." — OZ8SO

"No notch filter. Price." — AB6X

"SWR protection circuit is very sensitive and a really good matching network (tuner) is a must to achieve maximum output." — KM4U

"Price: A real nice radio but I think it is priced too high now at $1495.00." — KA2HYV

"Af gain control doesn't quiet the receiver." — DL7GK

"Drift during warm-up." — N2AQS

"There are just *no* bad features." — KH6JRZ

"No memories on second VFO. Poor quality dial mechanism."

"PTO drift."

"Counter reads out to only the nearest 100 Hz. Readout to nearest 10 Hz would be useful to meet military frequency standards (most are ±50 or ±25 Hz)." — WB2BOO

"Analog dial is hard to read." — Ed Clabough, Birmingham, Alabama.

"No phone-patch connection. I had to have mine modified." — K9ERO

"Low audio output." — K5FZ

"Weak audio." — W1OFZ

"Sensitivity to antenna SWR."

"No built-in notch filter. No way to completely defeat the AGC circuit." — W5AYZ

"As with all broadband solid-state no-tune radios, an antenna tuner/matchbox is required to match antenna, or rf shutdown will start about 3:1 SWR." — WB9HBH

"Sidetone not adjustable." — W3ODN

"Frequency creep." — W1AY

"Volume control can't completely cut off audio. Digital display hold button is useless. Auxiliary VFO shifts frequency when spot button is depressed." — WB9IWN

problems

Thirty-two percent of those completing questionnaires said they've had no problems with the TR7.

The most common problem encountered with the TR7, mentioned by 10 percent of the respondents to the questionnaire, was frequency drift. Other problems that cropped up were bad solder joints, leaky PIN diodes, problems with the tuning dial, and an occasional bad transistor. Bad solder joints were referred to by about 6 percent of those who replied. No other problems received significant attention from our respondents.

additional features

To the question, What additional features would you like to see built into a rig of this type?, the most frequent response was a notch filter, mentioned by 18 percent of the respondents. Next to the addition of a notch filter, the addition of a speech processor ranked high in the estimation of Amateurs responding. About 9 percent said that they would want to see some sort of speech processing incorporated into a rig of this type.

Other additional features that were mentioned were a phone-patch jack, programmable memories, a noise blanker, fm mode capability, a sidetone volume adjustment, an SSB squelch, and a built-in power supply.

accessories and related findings

The most popular accessory among owners of the TR7 is filters, which were purchased by about a third of those replying to the survey. However, we believe that about 75 percent of TR7 owners have actually purchased filters, which indicates that most of those responding to the survey didn't consider the filters as accessories. These include a-m, CW, and SSB filters. Next in popularity (18 percent) was a remote VFO, followed by speech processors, noise blankers, external speakers, and the service manual.

To the question, Have you had the rig serviced?, 51 percent answered yes and 49 percent no. Eighty-two percent of those whose rigs had been serviced said that the servicing was satisfactory. To the question, Have you been able to obtain all the accessories and parts you need?, 98 percent answered yes, indicating that Drake is certainly making their parts and accessories available to Amateurs. Ninety-four percent of those who purchased accessories were happy with them.

By license class, 45 percent of those responding to the questionnaire held an Advanced class ticket, 38 percent were Extras, 15 percent were Generals, and 2 percent were Technicians.

To the question, What antenna do you use most, 51 percent answered *beam*, 33 percent answered *wire*, 13 percent said *vertical*, and 3 percent replied *other*.

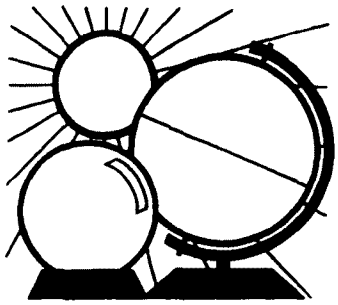
The following twelve categories were scored from 1 to 10 (with 1 being poorest, 4 to 6 average, and 10 perfect): Ease of Operation, Reliability, Durability, Instruction Book, Factory/Dealer Service, Quality of Workmanship, Performance, Maintenance, Parts Availability, Accessories (ease of connection), Price and Flexibility. The scores are reported in **fig. 1**.

would you buy one again?

That's the big question, and over 88 percent of the Amateurs responding answered yes. That's the highest positive response we've received thus far on any piece of high-frequency Amateur gear we've asked our readers about. Owners of the Drake TR7 are obviously very happy with their choice.

Next month, *ham radio* will present the results of its readers' survey on the Kenwood 520. This is a rig many Amateurs have asked to have reviewed, and the results should be interesting. Thanks to all who have participated by sending in a completed questionnaire.

ham radio



DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

The low-frequency bands, 160 through 40, will be the favored DX bands for the first two weeks of the month. The higher frequencies will then begin to improve and be very good for DX for the last week and a half. That means a good DX holiday, as well as the holiday of the plentiful harvest, for which we can be thankful. Disturbances, however, may develop about the 6th, 15th, and 26th. Remember: even though disturbance means signal strength and QSB problems on some paths, others may be a DX harvest of plenty. Keep looking.

November is a month of plentiful meteor showers going on from October 26 to November 22, with the shower maximum of ten per hour on the 3rd through the 10th. This shower is known as the Taurids. Lunar perigee is on the 12th, and full moon is the day before, the 11th.

November is often of special significance geophysically because of the quiet conditions of the geomagnetic field. November and December vie for being the quietest month of the year. By quietest is meant steadiness of the magnitude and direction at a point in the magnetic field as measured by a magnetometer (a very sensitive compass).

The variations of the geomagnetic field are described by the A figure on a daily basis. It is made from eight three-hour K figures. The K figure is the displacement from an average diurnal curve for an observing station during the three hours. Why does the geomagnetic field become more stable in winter (November, December, January)? One reason is the solar wind pressure against the earth's magnetic field (magnetosphere). Since the earth is closer to the sun in winter, the pressure at that time increases. This higher pressure around the magnetosphere holds it still — or tends to. In fact, the solar flux and geomagnetic field more often than not move opposite each other — except when the sun flares.

November is also the first month of the winter DX season. Although the hours of daylight in the Northern Hemisphere are quite short now, the ionospherically propagated frequencies rise rapidly with the rising sun each day. This maximum usable frequency (MUF) becomes very high, giving the 6-, 10-, and 15-meter bands a few afternoon and some evening hours of good DX.

The sunspot number (SSN) or solar flux is still high enough, now at the beginning of the decline of the SSN cycle, to produce openings on these bands. The high ionization piles up on both sides (±20 degrees) of the geomagnetic equator. A mound of ionosphere above Central America and northern Argentina allows transequatorial one-long-hop signals into the southern populated areas of South America. The late evening hours, 2000-2300 local time, are the optimum times for DX to our friends down south. A bit of geomagnetic disturbance even makes this type of propagation better.

The noise (QRN of the spring, summer, and fall thunderstorms) is about over by now. This lack of QRN now makes DXing in the lower bands of 80 and 160 meters a pleasure. So you can see why November ushers in the winter DX season, and now you have more time indoors to enjoy it.

band-by-band summary

Six meters will open occasionally for F2 long skip propagation with hops 1000 to 2500 miles long, and with many hops usable. The openings will follow the sun during the day and early evening.

Ten and fifteen meters will have openings similar to those on 6 meters, but more often and lasting longer. Worldwide DX is usual from after sunrise until well after sunset during periods of the 27-day solar flux maxima. Short skip of 1200 miles maximum distance is also possible, and will also be following the sun across the earth.

Twenty meters will be open most all days and nights to some area of the globe, with long skip, and some short skip. Distances and number of hops will be much like those on the 15-, 10-, and 6-meter bands.

Forty and eighty meters will be the most usable night-time bands for DX. Most areas of the world can be worked from dusk till just before sunrise. Hops shorten on these bands to about 2000 miles for 40 and 1500 miles for 80 meters, but the number of hops can increase since signal absorption in the ionospheric D region is low during the night. The path direction follows the darkness across the earth, similar to the higher bands following the sun. Daytime short skip can be used during the day and at night if low-height horizontal antennas (high take-off angle) are used. Vertical antennas over good ground systems give the lowest take-off angles for long skip on these bands.

One-sixty meters will be about like 80 meters and provide good stuff for the enthusiastic DXer who likes to work into the wee hours of the night and early morning hours — maybe you retired folks or swing shift workers.

ham radio

*Look at next higher band for possible openings.

GMT	PST	WESTERN USA N	NE	E	SE	S	SW	W	NW	MST	MID USA N	NE	E	SE	S	SW	W	NW	CST	EST	EASTERN USA N	NE	E	SE	S	SW	W	NW
0000	4:00	10	20	10	10	10	10	10	10	5:00	—	20	15	15	10	10	10	10	6:00	7:00	15	20	15	15	15*	10	10	15
0100	5:00	10	20	15	10	15	10	10	10	6:00	—	20	15	15	10	10	10	15	7:00	8:00	15	20	20*	20	15	10	10	15
0300	6:00	10	20	15	15	15	10	10	10	7:00	—	20	20*	20	15	15	10	15	8:00	9:00	—	20	20	20	15	15	15	20
0300	7:00	10	—	15	15	15	10	10	15	8:00	—	20	20	20	15	15	15	15	9:00	10:00	—	20	20	20	15	15	15	20
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0600	10:00	—	—	20	20	15	15	15	20	11:00	—	40	20	40	20	20	20	—	12:00	1:00	—	40	20	20	20	20	20	20
0700	11:00	—	—	20	20	20	15	15	20	12:00	—	40	20	40*	20	20	20	20	1:00	2:00	20	40	20	20	20	20	20	20
0800	12:00	20	—	20	20	20	20	20	40	1:00	—	40	20	20	20	20	20	20	2:00	3:00	20	40	40	40	20	20	20	20
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1000	2:00	20	20	20	20	20	40	20	40	3:00	—	40*	—	40	20	20	—	20	4:00	5:00	—	—	—	40	—	20	20	—
1100	3:00	20	—	—	40	20	40	20	40	4:00	—	—	—	40	20	20	—	20	5:00	6:00	—	—	—	20	—	—	—	—
1200	4:00	20	—	—	40	40	40	20	40	5:00	20	—	—	20	20	—	—	—	6:00	7:00	—	—	10	10	—	—	—	—
1300	5:00	20	—	—	40	40	40	40	40	6:00	20	20	—	15	20	—	—	—	7:00	8:00	—	20	10	10	—	—	20	—
1400	6:00	20	20	20	20	—	40	40	—	7:00	20	20	10	10	—	—	20	—	8:00	9:00	20	15	10	10*	—	—	15*	—
1500	7:00	20	20	15	15	—	40	20	—	6:00	15	15	10*	10*	—	20	15*	—	9:00	10:00	20	10	10*	10	—	—	15	20
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1700	9:00	15	15*	10	10	—	15	15	—	10:00	15	15	10	10	—	15	15	—	11:00	12:00	10	10	10	10	—	10	15	—
1800	10:00	15	15	10	10	15	10	15	—	11:00	15	15	10	10	—	10	15*	—	12:00	1:00	10	15	10*	10	15	10	15	—
1900	11:00	15	15	10*	10	15	10	15	20	12:00	15	15	10	10	15	10	15*	—	1:00	2:00	10	15	10*	10	15	10	15	—
2000	12:00	15*	15	10*	10	15	10	10	15	1:00	15	20	10	10	15	10	15*	20	2:00	3:00	—	15	10	10	10	10*	15	20
2100	1:00	10	20	10	10	15	10	10	10	2:00	—	20	10	10	10	15*	15	15	3:00	4:00	—	15	10	10	10	10	10	15
2200	2:00	10	20	10	10	15	10	10	10	3:00	—	20	15	10	10	15*	10	10	4:00	5:00	—	20	15	15	10	10	10	15*
2300	3:00	10	20	10	10	15	10	10	10	4:00	—	20	15	15	10	10	10	10	5:00	6:00	—	20	15	15	10	10	10	15
	NOVEMBER	ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN		ASIA FAR EAST	EUROPE	S. AFRICA	S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN			ASIA FAR EAST	EUROPE	S. AFRICA	CARIBBEAN S. AMERICA	ANTARCTICA	NEW ZEALAND	OCEANIA AUSTRALIA	JAPAN



portable two meter quad

A new collapsible antenna has been introduced by Palomar Engineers. It extends the range of low power 2-meter transceivers by providing the gain and front-to-back discrimination of a two-element quad. It is ideal for boating, backpacking, mountaintopping and other portable applications, since it gives the gain of a linear amplifier but does not require additional battery power.

The entire beam assembly is housed in an 18-inch carrying case that will fit in a suitcase. For use, it unfolds to form a two-element full size quad complete with stablized mounting stand. The portable two-meter quad sells for $67.50. For further information write Palomar Engineers, 1520-G Industrial Avenue, Escondido, California 92025.

communications accessories brochure

A new four-page brochure describing communication acessories that are essential to operating excellence are now available from the J.W. Miller Division of Bell Industries in Compton, California.

Antenna tuners Model AT 2500 with 2500 watts PEP power capability and Model CNA-1001 for 500-watts PEP cover a frequency range of 3-30 MHz including the WARC bands. Direct-reading meters provide forward and reflected power indications and SWR. Models CN-720-B and CN-620-B cover 1.8-150 MHz, and Model CN-630 covers 140-450 MHz. Rf clipping that ensures low distortion is provided by the Model RF-440 speech processor. Adjacent-channel isolation of better than 50 dB at 300 MHz and 45 dB at 450 MHz is provided by the CS-201 two-posititon and CS-401 four-position coaxial switches.

Additional infomation may be obtained from Joe Johnson, J.W. Miller Division, Bell Industries, P.O. Box 5825, Compton, California 90224.

portable power systems

Heath Company announces the Heathkit GU-1820 portable power system. This lightweight alternator can produce up to 2200 watts of 120 Vac, 60-Hz power — enough to operate a ham station, an electric chain saw, or a refrigerator-freezer during a blackout. The GU-1820 is designed for ham radio clubs, home owners, civil defense, police and fire departments. It can also provide on-location power for construction and logging crews, campers, hunters, wood cutters, and others.

Mail order price is $479.95. Voltage is regulated to within ±5 percent, and frequency variations are limited to ±4 Hz, from no load to full load at 3600 RPM. Radio-frequency interference is eliminated by a resistive spark plug.

The five horsepower Briggs and Stratton gas engine can run up to 1-3/4 hours, at half load, on a tankful of regular gas, unleaded gas or gasohol. Noise is controlled by a low-tone muffler; to reduce sparking to a minimum, the optional GUA-1820-1 spark-arresting muffler ($3.95 mail order; required in California) is available.

For more information, contact Heath Company, Dept. 350-035, Benton Harbor, Michigan 49022.

2-meter amplifiers

Heath Company announces two new high-power amplifiers for Amateur Radio operators using the 2-meter band. The VL-2280 75-watt VHF base amplifier is suited for base or mobile use.

Both the VL-2280 and the VL-1180 amplifiers are designed to operate in all modes (single sideband, fm or CW), across the entire 144-148 MHz 2-meter band. Ten watts in produces 75 watts out. Antenna-to-receiver insertion loss is less than 0.6 db, and intermodulation distortion is less than 24 dB. Power output is kept stable across the entire band by broadband circuitry. Extra-large heatsinks provide enough cooling to make possible a 50-percent duty cycle. Keying can either be rf-sensed or remote.

The VL-1180, priced at $137.95 (FOB Benton Harbor, Michigan), operates on 13.6-Vdc mobile power. A special design allows the VL-1180 to be used in a car trunk or other out-of-the-way place.

For more information contact Heath Company, Dept. 350-056, Benton Harbor, Michigan 49022.

high-isolation coaxial relay

The Dow-Key Division of Kilovac Corporation has released for sale a new high-isolation SPDT coaxial relay. The model 66-23732 was developed primarily for use with cable television head-end equipment, and features the 75-ohm "F" female connectors, which provide a minimum of −100 dB isolation dc to 500 MHz. The relay comes equipped with 26.5-Vdc actuating coil and DPDT auxiliary contacts. Power capacity is 20 watts CW.

The relay is designed for video source switching, using the auxiliary contacts for audio follow-on. It has excellent rf characteristics for i-f switching, and the auxiliary contacts may be used for remote indication of the relay position. The same relay is ideal for rf switching to 500 MHz, and for use in remotely actuated or programmable switching modules. The model 66 is also available with a 12-Vdc coil, with or without auxiliary contacts. For further information contact: Kilovac Corporation, P.O. Box 4422, Santa Barbara, California 93103.

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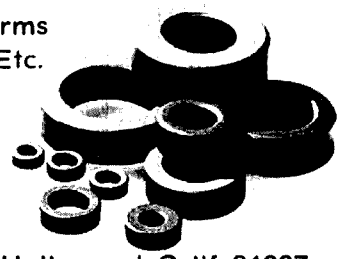
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heavy duty portable DMM

The new rugged HD-100 from Beckman Instruments, Inc., is made waterproof and dustproof to resist the elements. It can withstand the physical impact of accidental drops and has the kind of built-in input protections never before found in other DMMs.

Voltage inputs are protected to 1500 Vdc or 1000 volts RMS. Current ranges are protected to 2 amps/250 volts while resistance changes are protected to 500 Vdc. The O-ring sealed ABS plastic case is fire retardant with ribbed side walls that are twice as thick as in other meters. The bright NATO-yellow case is highly visible — easy to spot in a tool box or on a ledge before leaving a job.

For further information and complete specifications, contact your local electronics or meter distributor, electronics retail outlet or Beckman Instruments, Inc., Advanced Electro-Products Division, 2500 Harbor Blvd., Fullerton, California 92634.

catalog for power grid tubes

A quick-reference catalog for power grid tubes is available free from Varian/Eimac. The catalog lists tubes manufactured at Eimac's San Carlos and Salt Lake City sites. The San Carlos plant produces large ceramic/metal power grid tubes, cavities, and accessories. Glass power tubes, smaller ceramic/metal tubes, and a wide line of planar triode and X-ray tubes are manufactured in Salt Lake City.

Included in the catalog is an applications-oriented power grid tube se-

Tell 'em you saw it in HAM RADIO!

lection guide for ease in making type selections. To receive the free, quick-reference catalog of Eimac power grid tubes, contact the nearest Varian Electron Device sales office or Varian/Eimac, 301 Industrial Way, San Carlos, California 94070.

station clock

The heart of the Zulu 3TZ is a microprocessor chip and memory that gives it greatly expanded capabilities. Besides the one local 12-hour time zone and two alternate 24-hour world time zones, the unit has a reminder I.D. timer that gives different tones at 8, 9, or 10 minute intervals. The IDer is resettable and accurate to plus or minus 0.1 second. Other features include large, orange 0.6 inch LED readouts for easy readability; quartz crystal timebase battery backup; ac or dc operation on 12 volts or 117 Vac with the wallplug transformer that is included.

Also useful is an appliance timer output that is synchronized with the local (12-hour) time that allows one on and one off shiftpoint per day. The manual explains how to connect the appliance-timer output to a relay or triac (not included) to control any external device. The unit can be made to display remote temperature using a silicon linear thermistor probe and a highly stable voltage-to-frequency circuit. The additional parts are available for $9.95. Contact Bullet Electronics, P.O. Box 401244, Garland, Texas 75040.

MBA reader-only

AEA, Inc., announces the introduction of a reader for Morse, Baudot, and ASCII operation. Designated the MBA-RO (reader only), it is a state-of-the-art device using a 32-character vacuum fluorescent alphanumeric display. The 32-character display allows for up to five words to be displayed at one time. This extended display is especially useful during high-speed copy.

The reader can copy up to 99 WPM for CW, 60-70-75 and 100 WPM for

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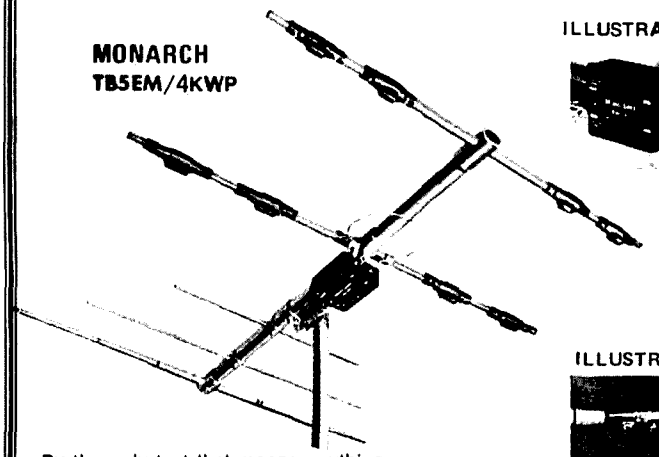


ILLUSTRATION BALUN

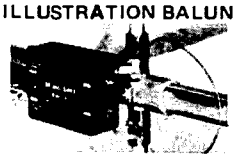


ILLUSTRATION TRAP

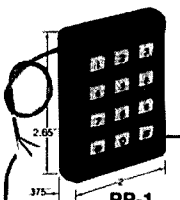


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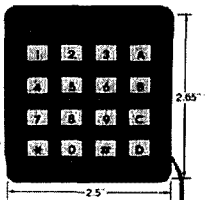
For technical data and prices on complete Telrex line, write for Catalog PL 7

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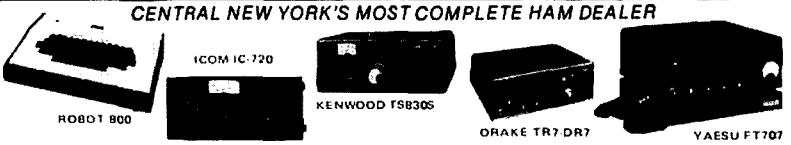
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short circuits

wideband sweep generator

The following correction should be made to fig. 2 in the article "Stable Wideband Sweep Generator," which appeared in the June, 1981, issue: The 100k resistor between R3 and pin 2 of the 741 IC should be connected between pins 2 and 6. The side of R3 that is shown connected to the 100k resistor should be connected to pin 6.

antenna bridge calculations

The following errors appeared in the program listed in K6GK's article in the March, 1981, issue (page 85).

Line 160 is missing an end bracket. Line 640 should have no bracket. Line 350 should read +1+2, not =1+1. Line 400 should read (A2*B1) not (A2+B1). Line 610 should read −I4, not I4.

Line 390 is an overlooked "garbage" term and can be scratched. The program "just growed" and can be shortened a bit, but it was submitted as is in the hope that it would stimulate interest in this approach.

G3LDO wire beam

Please note that in fig. 7 of Bill Orr's article, "Ham Radio Techniques," in the January, 1981, issue, the dimension D should have been indicated on the drawing as the distance from the top of the vertical mast to the point at which the support rods cross.

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Grampa Ronnie??
Uncle Hohmer?

If not . . . see page 92.

Coming Events

ACTIVITIES

"Places to go..."

INDIANA: The Allen County Amateur Radio Technical Society's 9th annual Hamfest, November 15, 8 AM to 4 PM, Allen County Memorial Coliseum, Ft. Wayne. Admission: $2.50 advance, $3.00 door. Children 11 years and under free. Large flea market, forums, door prizes. Talk-in on 148.28/.88. Tables $6.00 each. Premium tables $20.00. For information or pre-registration: Allen County ARTS, P.O. Box 10342, Ft. Wayne, IN 46651. Att: Hamfest Committee.

MICHIGAN: The 16th annual Hazel Park Amateur Radio Club's Swap & Shop, Sunday, December 6, Hazel Park High School, Hughes Street, 9½ Mile Road, 1 mile east of I-75, Hazel Park. Tickets $2.00. Tables 75¢ per foot. Doors open 8 AM. Main prize drawing 2 PM plus hourly prizes. Grand prizes included with admission ticket. Talk-in on 146.52. For information: SASE to Jack Field, WA8UPU, 1444 E. Evelyn, Hazel Park, MI 48030.

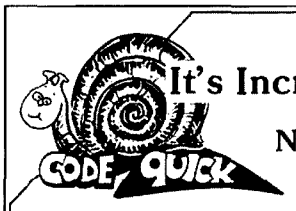
MICHIGAN: The Oak Park High School Electronics Club's 12th annual Swap & Shop, Thanksgiving Sunday, November 29, Oak Park High School, Oak Park. Admission: $1.50 advance, $2.00 door. 8 ft. tables $5.00 advance, $6.00 door. Door prizes and refreshments. For tickets and reservations: SASE to Herman Gardner, Oak Park High School, 13701 Oak Park Blvd., Oak Park, MI 48237. Or call (313) 968-2675.

OPERATING EVENTS

"Things to do..."

DECEMBER 4, 5, 8. The Pike County Amateur Radio Club of Winslow and the Old Post Amateur Radio Society of Vincennes will operate a special events station from Santa Claus, Indiana. Call sign W9CZH. Time 0000 Z on December 4 through 2300 Z December 6. Frequencies: 21.410, 14.305, 7.270, 3.925. All SSB, 14.090-14.100 RTTY and 146.52 FM. A special QSL/XMAS card postmarked from Santa Claus post office sent upon receipt of SASE to Santa Claus, P.O. Box 111, Ireland, IN 47545.

DECEMBER 5, 6, 7. The 17th annual Telephone Pioneers QSO party, 1900 UTC, December 5 through 0500 UTC, December 7. CW call CQTP. Phone call CO Telephone Pioneers. Phone frequencies: 3.955-3.975; 7.265-7.285; 14.285-14.305; 21.355-21.375; 28.665-28.885; 50.10-50.25; 144.275-145.500 and 146.52. CW frequencies: 3.555-3.575; 7.055-7.075, 14.055-14.075; 21.055-21.075; 28.055-28.075; Novice/tech: 3.725, 7.125, 21.125, 28.125. Send logs by January 15, 1982 to: Ted Phelps, W8TP, John D. Burtle Chapter No. 89, Telephone Pioneers of America, c/o Western Electric, Dept. 45150, 8200 East Broad Street, Columbus, OH 43213.



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214 Electret Mic for 234. . . . . List $39 . . . . . SALE $ 36
216PC Ceramic Mic. . . . . List $35. . . . . SALE $ 29
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229 2KW PEP Tuner w/SWR Meter. . List $269. . SALE $ 229
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V71	2 mtr. 1-3W in · 90W out amp w/PS	$349
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V350	2 mtr. 10-20W in · 400W out amp w/PS	$949
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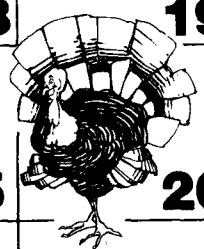
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More Details? CHECK—OFF Page 102

HAM CALENDAR

November

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
8TH ANNUAL U.S. MARINE CORPS MARATHON — beginning 0900 EST. Frequencies used will be: All 2-meter repeaters in the D.C. area; 10-meter FM & single-sideband in vicinity of 29.6 and 28.5 MHz; 15-meters in vicinity of 21.360 MHz; 40 meters in vicinity of 14.3 MHz; 40 meters in vicinity of 7.225 MHz. Operators who complete their QSO's with N3ES via W3NKF send their QSL cards to W3NKF, Code 9015, Naval Research Lab, Washington, D.C. 20375. 1 **DEFIANCE COUNTY HAMFEST & FLEA MARKET** — Defiance County Fairgrounds, Hicksville, OH. Contact Ed Ballard, Jr., WD8JVV. 1 **1**	**WEST COAST BULLETIN** — 8PM PST (0400UTC), 3540 KCS, A-1, 22 WPM. 2 **2**	**AMSAT** East Coast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **3**	**YLRL ANNIVERSARY PHONE CONTEST.** 4-5 **4**	**5**	**6**	**ARRL SWEEPSTAKES (CW).** 7-8* **7**
R.F. HILL ARC 5TH ANNUAL HAMFEST — Sellersville National Guard Armory, Sellersville, PA. Contact K3TV for more information. 8 **8**	**9**	AMSAT East Coast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **10**	**W1AW QUALIFYING RUN.** 11 **11**	**12**	**13**	**ESPERANTO (ILERA)** Details from G4MR, QTHR 14-15 **NORTH CAROLINA QSO PARTY.** 14-15 **EUROPEAN DX CONTEST** — see July *QST* 14-15 **14**
ALLEN COUNTY AMATEUR RADIO TECHNICAL SOCIETY 9TH ANNUAL HAMFEST — Allen County Memorial Coliseum, Ft. Wayne, IN. Contact Allen County ARTS, P.O. Box 10342, Ft. Wayne, IN 46851. 16 **15**	**WEST COAST BULLETIN** — 8PM PST (0400UTC), 3540 KCS, A-1, 22 WPM. 16 **16**	**AMSAT** East Coast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **17**	**18**	**19**	**20**	**W1AW QUALIFYING RUN.** 21 **ARRL SWEEPSTAKES (phone).** 21-22* **21**
22	**23**	**AMSAT** East Coast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **24**	**25**	 **26**	**27**	**CQ WORLDWIDE DX CONTEST (CW).** 28-29 **28**
OAK PARK HIGH SCHOOL ELECTRONICS CLUB 11TH ANNUAL SWAP & SHOP — Oak Park High School, Oak Park. For more information send SASE to Herman Gardner, Oak Park H.S., 13701 Oak Park Blvd., Oak Park, MI 48237. 29 **29**	**30**	**AMSAT** East Coast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **31**				*See October *QST*.


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DECEMBER 1981

volume 14, number 12

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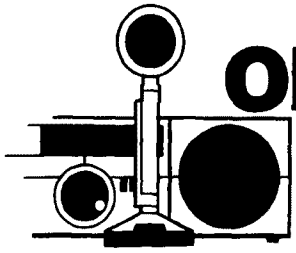
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Observation & Opinion

This month I'd like to introduce a close friend and fellow Californian, Bill Gay, WA6PNY. Bill and his wife visited us on the last leg of an extensive trip across Canada that lasted 2½ months. They met many Amateurs and had a wonderful time operating their station, which was installed in a 31-foot trailer. Here are some of their experiences and a look at what other American hams might expect from our colleagues up north, in Bill's own words. **Editor.**

The hospitality extended to my wife and me by Canadian Radio Amateurs during our trailer trip across that country is something I'll never forget. Trailering with a mobile ham station is a great way to make friends, and I want to thank all the hams I met from British Columbia to Quebec for their warmth and generosity.

I had no idea what was involved in obtaining permission to operate in Canada. I wrote to the Canadian Department of Communications for information and even included a copy of my license. I was told just to bring my gear and operate as if I were in the U.S. No fuss, no bother. With the reciprocal licensing agreement, I was allowed to work essentially all the ham bands with the same privileges I have at home as an Advanced-class licensee.

We had no problems whatever crossing into Canada.

"Where are you from?"

"San Diego."

"Where are you going?"

"Across Canada!"

"How long are you going to be in the country?"

"Two or three months."

"Okay, go ahead."

Unbelievable! I was prepared to pay duty on food, my equipment, and so forth, but there was no inspection and no hassle.

One of the highlights of the trip occurred after we'd stopped at a KOA campground just outside Calgary. I called Fred Dettmers, VE2BQY, (whom I'd met previously) on the radio and asked if there was an autopatch on the local repeater. I was told, "Oh yes. Standard access: star up; pound down." I was amazed! No secret codes, no PL tones — just star up and pound down. Another example of Canadian hospitality.

While visiting with Fred and his wife, I had an opportunity to obtain an insight into the differences between Amateur Radio in Canada and the United States. Consider, for example, that the Amateur population in Canada is only about 21,000, compared with 53,000 in California alone. It's easy to understand the concern of the Canadian ham who must contend with the terrific wall of signals coming up from south of the border, especially when Canadians are trying to work into Europe.

The licensing structure in Canada is interesting. Three classes of license are offered: Amateur, Advanced, and Digital. For the Amateur license, the applicant must pass a ten-WPM code test, a written exam, and an oral exam. This license class grants all-band privileges, code only, plus VHF phone. After six months and proof of at least twelve contacts, a 10-meter-phone endorsement and full power privileges are granted. The Digital license allows digital operation at VHF/UHF.

The Amateur-class licensee is eligible to apply for the Advanced license after one year. This exam consists of a fifteen-WPM code test and another written test. The Advanced license permits full band and mode privileges. After five years, the Advanced-class Amateur may obtain a two-letter call sign if available. Licenses are issued for five years, with an annual fee payable to the DOC.

Our trip lasted 2½ months. I had a chance to operate in all the VE districts except VE1 and to meet a fine group of people. One real challenge was a request I received to explain the new Amercian call sign system. It seems that no one in Canada really understands what's going on, who's who, or what's what with our new calls. I'm not sure *I* understand *either*.

Bill Gay, WA6PNY



comments

coaxed into noticing

Dear HR:

Your July article "Buying Parts By Mail" left out a very reliable source of coaxial cable and other parts. Please notice that Nemal Electronics (5685 S.W. 80th St., Miami, Florida 33143) has a wide selection of coaxial cable and cable accessories for sale at very attractive prices. In addition to that, their service is excellent. I can usually expect to get my order from them in little more than a week's time. Next time you need something in the cable line, I suggest you give them a call.

Dave Karpiej, K1THP
Plainville, Connecticut

a new breed

Dear HR:

What is wrong with this new breed of Amateur operator? Is it that we're friendly, considerate, and delighted with the idea of being a ham operator? When I was young we looked upon ham operators as elitists — eccentric individualists, mostly rich and *kooky*. Well, times have changed, what with the age of electronics and with the advent of inexpensive Citizen-Band Radio, and many of us who suffered through the changes on 11 meters have migrated to ham radio.

There are those of us who will become the ideal ham operator, knowledgeable in all phases of electronics, capable of tearing a radio apart and arranging it in perhaps better-than-new condition. And there will be those of us who will wish we could but cannot, who will resort to the Bash book and memorization in order to escape the trials of 11 meters. It behooves the well-versed Amateur operator to use his expertise to help others and to turn his attention to more constructive matters — perhaps new rules and regulations to replace antiquated ones.

So I say Viva La Nuevo Amateur operator and remember you are now a part of the elite. Handle it with dignity and care and to you who did it the hard way — understanding is the name of the game.

Judith M. Stevens, KA4IZU
Clearwater, Florida

RFI cures

Dear HR:

In regards to John Frank's article about RFI (September, 1981), I think the rule of thumb he speaks of in reference to **fig. 2** is misleading. The rule is implemented when no ac signal is desired across the resistor being bypassed, as in an emitter or cathode lead. This is not the case for a preamp input. The rule should be tied to the interfering signal. The bypass cap must have a high impedance with respect to the circuit impedance at the highest audio frequency presented to the amplifier.

Al Izatt, WB7SYB
Aberdeen, Washington

Part of the problem in selecting bypass capacitors for RFI cures is that there are two frequencies involved (audio and radio), and we want to bypass only one of them.

The rule of thumb I mentioned in my article provides a starting point for determining how much capacitance should be added to bypass rf without affecting audio. The optimum value of the bypass capacitor will depend on the impedances involved, the severity of the interference, and the frequency of the offending signal.

My own experience shows that bigger is not necessarily better when you are adding bypass capacitors to cure RFI. I prefer using the smallest amount of capacitance that will solve the RFI problem.

John W. Frank, WB9TQG
Madison, Wisconsin

low SWR

Dear HR:

I enjoyed the article by Stan Gibilisco, W1GV/4, entitled "How Important Is Low SWR?" in the August, 1981, issue. It is an excellent article and I believe it will help many people, especially me. I believe, however, that there is one small mistake in **fig. 2**. All the cable losses are off by a factor of two. This I believe is because the cable loss is actually one-half the measured value because the measured value is a two-way cable loss. I refer you to the article by K9MM.*

John Biro, K1KSY
Chelmsford, Massachusetts

In response to the letter from John Biro, K1KSY, I have performed my own calculation, as follows:

Let m = *line loss when matched;*
E = *"forward" voltage as measured at transmitter;*
e = *"reflected" voltage as measured at transmitter*
r = *SWR;*
ρ = *reflection coefficient* = $(r-1)/(r+1)$

Then, with the far end of the line short-circuited,

$$-2m = 20 \log_{10} (e/E)$$
$$= 20 \log_{10}(\rho) = 20 \log_{10} [(r-1)/(r+1)]$$

Thus $m = -10 \log_{10} [(r-1)/(r+1)]$

This formula produces results that agree with John's and show that ***fig. 2*** *in my article is in fact off by a factor of 2.*

Stan Gibilisco, W1GV/4
Miami, Florida

*John E. Becker, K9MM, "Calculating Feedline Loss with a Single Measurement at the Transmitter," *ham radio*, June, 1978.

presstop

PROJECTED FCC STAFF CUTS could drastically alter the agency over the next two years. According to Communications Daily of October 8, over 500 Commission jobs are due to be cut during fiscal 1982 and 1983. The Reagan-administration-mandated cuts will be particularly severe in the Private Radio Bureau, which had 258 positions (250 of them filled) when fiscal 1981 ended. It's to be reduced to only 193 people in the next 12 months, and to 176 the following year. Of the Bureau's present 250 people, 145 work in licensing at Gettysburg and are thus considered essential. As a result, all of the PRB's cutback will be in Washington, where it employs 105. The planned reduction will leave only 31 people doing the Bureau's Washington work two years from now! This will undoubtedly mean a great deal of workload doubling up, with the attention paid to each of the services the Bureau administers reduced accordingly.

The Field Office Bureau will fare just as poorly under the recently announced plans, with its staff to be reduced from the present 455 to 311. A number of Field Offices will have to be closed, and the services provided by others drastically reduced. Enforcement efforts will also have to be sharply curtailed as well. Of course, other FCC bureaus will also be feeling the pinch, and there's even a rumor the FCC's Laurel (Maryland) Lab will close.

Some Key Provisions of Senator Goldwater's bill, S.929, take on a new meaning as the impact of the FCC cutback sinks in. Amateurs administering exams, and taking an active part in enforcement, could help the Commission greatly should it no longer be able to properly support these activities itself.

Chairman Fowler Has Announced his intention to seek a relaxation of the projected cuts from the Office of Management and Budget. Because of the importance of the FCC to a healthy Amateur Service, Amateurs could do themselves a service by asking their Congressmen to provide more FCC funding.

SENATOR GOLDWATER'S PRO-AMATEUR RADIO BILL was passed by the Senate September 25 by unanimous consent. This important piece of legislation, S.929, would affect not only the Amateur Service but would also affect CB and radio control licensees as well as the electronics manufacturing industry.

Establishment Of RFI Susceptibility standards for the TV and home entertainment electronics industry could well be the most significant result of this comprehensive bill, if it becomes law. It would vest in the FCC the authority to set such standards, as a means of reducing escalating RFI problems. It would also increase the term of an Amateur license from five to ten years, while a last-minute amendment by Senator Goldwater would also permit the FCC to discontinue the licensing of CB and radio control operators entirely, a deregulatory measure that has received some support from both FCC staff and Commissioners recently. In addition, it would specifically exempt Amateur transmissions from the secrecy provisions (Section 605) of the Communications Act. Though it was long assumed that Amateurs were not included in Section 605 coverage, recent legal decisions have generally applied its limitations to Amateur operations.

The Commission Could Enlist Volunteer assistants from both the Amateur Radio and CB communities, under still another provision of Senator Goldwater's bill. These volunteers would be permitted to work directly with FCC engineers in monitoring both Amateur and CB frequencies for unlicensed or otherwise improper operations. Amateur Radio licensees would also be permitted to serve as volunteer examiners for "entry level" Amateur license applicants, a long-standing practice in Amateur Radio that has recently been termed "illegal" under present laws by the FCC legal staff.

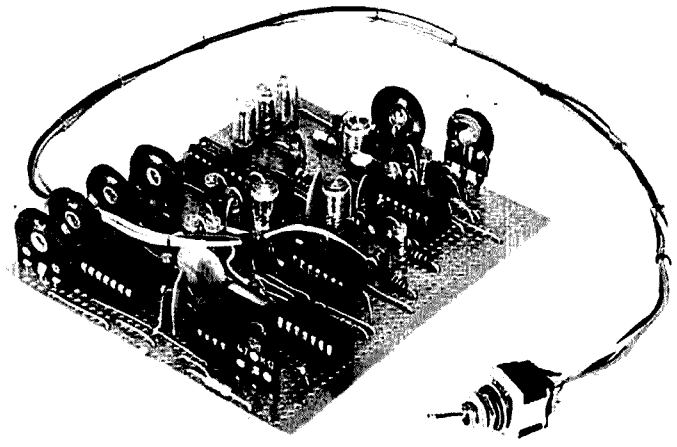
One Key Provision Of S.929, as introduced by Senator Goldwater, was not included in the bill the Senate passed. This was the provision that would have given the Commission the power to restrict the purchase of transmitting equipment to those having the appropriate license to use it. Though generally supported by the Amateur community, this provision contradicts the deregulatory philosophy of the present administration.

The Next Step For S.929 is in the House of Representatives, where it could be tied to appropriate legislation already pending there. More likely, it will be considered by itself, possibly replacing existing legislation such as Rep. Dannemeyer's HR 2203. It will go to the House Committee on Communications, chaired by Rep. Timoty Wirth, and it's possible that some action could be taken on it by early next year.

Support Of S.929 By Amateurs, expressed to their Representatives, should help to keep the bill moving toward passage.

AVAILABILITY OF THE NEW 10-MHZ BAND looks farther and farther away. First, the WARC treaty hasn't yet been ratified by the Senate, and, though that could happen soon, until it does there will be little further FCC action on new allocations. When those new allocations do become official, by revision of Part 2 of the FCC Rules, U.S Amateurs will still face a rule-making proceeding to determine how the new band will be used: class of licensee, power, and type of emissions. At best, the whole procedure could take many months, and with the severe staff cuts the Commission is facing it could stretch out indefinitely.

10-MHz Operation on January 1, 1982, is expected by Amateurs of a number of countries whose administrations have already implemented the WARC changes.



an a-m/fm converter for facsimile transmission

A circuit that features input and output lowpass filters and a VCO

In recent years, facsimile transmission by Amateur Radio has been attracting increasing interest.[1] Thus, since September, 1980, the official bulletin of the DARC is regularly transmitted in facsimile by DJ8BT at Frankfurt. Most Amateur stations operating in this mode are using second-hand commercial or military equipment, although a number of home-built facsimile recorders are in use as well.

In the facsimile transmitter, the picture or document to be transmitted is scanned photoelectrically, the resulting video signal being used to amplitude modulate a carrier of constant frequency, conventionally in the range from 1300 to 1900 Hz. The modulated carrier is sent via a line or radio channel to the facsimile recorder, which converts the amplitude variations into a copy of the original picture or document.

The amplitude-modulated facsimile signal is most suitable for transmission over line circuits, where the transmission-loss variations with time can be kept within ±1 dB. When sent by radio, however, especially over long-range circuits, it is particularly vulnerable to amplitude changes caused by fading. One solution to this problem is the transmission of the a-m facsimile signal by a frequency-modulated voice channel of sufficient quality, thus employing double-modulation technique (emission F4 with amplitude-modulated subcarrier). Due to the large bandwidth required, this procedure is confined to UHF.

high-frequency radio transmission

For high-frequency radio circuits, therefore, other techniques have to be used. One implies that the a-m signal from the facsimile scanner is demodulated to produce the video signal, which is then used for modulating the carrier frequency of the high-frequency transmitter (emission F4 without subcarrier). For most purposes, the frequency is chosen to be f_0 − 400 Hz for white and f_0 + 400 Hz for black, f_0 being the nominal transmitting frequency.[2] However, for meteorological charts the black and white limits are reversed, and on low-frequency circuits the limits f_0 ± 150 Hz are used.[3]

Alternatively, the a-m facsimile signal is converted into an audible frequency-modulated signal, which is then used to modulate a high-frequency radiotelephone transmitter (emission A4 with frequency-modulated subcarrier). Especially, if a properly adjusted SSB transmitter is used, the emission (A4J with fm subcarrier) will be equivalent to F4 without subcarrier. This is the method preferred by the International Radio Consultative Committee (CCIR). As a standard, the subcarrier frequency is set to 1500 Hz for white and 2300 Hz for black,[2] with the limits reversed for weather charts.[3]

Because most commercial and military facsimile apparatus on the surplus market lacks the fm-subcarrier facility, the need arises for modulation conversion when such apparatus is to be used on high-frequency channels. Whereas an a-m/fm converter is always required at the transmitting end, the F4 signal can often be received rather satisfactorily without any additional equipment, simply by detuning the high-frequency receiver. However, fm/a-m converters are available, like the one recently described by PE1CMX.[4]

The facsimile apparatus I use is an FX-1-B, one of the classical facsimile transceivers designed and manufactured in the early 1940s by the Times Facsimile Corporation for the U.S. Army Signal

By Karl-Gustav Strid, SM6FJB, Sofiagatan 83, S-416 72 Gothenburg, Sweden

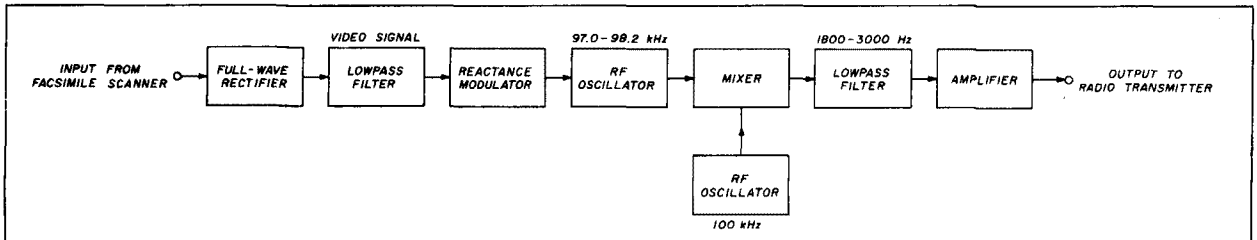


fig. 1. Block diagram of transmitting portion of facsimile converter CV-2/TX.

Corps. Part of facsimile equipment RC-120-B, it scans an 18 × 22 cm original at 90 strokes per minute with index of cooperation $M = 264$. The transmitted signal consists of an amplitude-modulated 1800 Hz carrier, the contrast (that is, the level difference between white and black) amounting to 8-15 dB, depending on the recording technique employed at the receiving end. For such a set to be useful on long-range radio circuits, modulation converters for both the transmitting and the receiving end were designed and built. As a basic requirement, fm transmission was to conform with the 1500/2300 Hz standard. Furthermore, the contrast of the a-m signal was to be adjustable to any value up to 30 dB, positive or negative.

design of a transmitting converter

As an example of an existing facsimile a-m/fm converter, **fig. 1** shows the block diagram of the transmitting circuits of facsimile converter CV-2/TX used by U.S. Army Signal Corps.[5] The a-m facsimile signal is full-wave rectified and the carrier frequency suppressed by a lowpass filter. The video voltage thus produced is passed to a reactance-modulator stage controlling the frequency of an oscillator working slightly below 100 kHz. Beating this variable-frequency output with that from a fixed oscillator at 100 kHz yields the desired audible fm signal, which after lowpass filtering and amplification, is fed to the microphone input of the radio transmitter. (A similar heterodyne technique has been used by HA5WH for generating teleprinter AFSK signals.[6])

The present design is based on a different approach, as shown in **fig. 2**. The video signal obtained by full-wave rectification and lowpass filtering of the a-m facsimile signal is used, after contrast adjustment, to control the frequency of a square-wave oscillator, whose output is lowpass filtered to produce a sinusoidal fm signal.

The a-m facsimile signal may be presented to the converter with either positive or negative contrast. In the former case the white level is nominally 1 mW across 600 ohms (775 mV), the black level lying 8 to 30 dB lower; in the latter case these levels are reversed. The fm signal ouput to the radio transmitter conforms with the recommendations of the CCIR and the International Telegraph and Telephone Consultative Committee (CCITT),[2] white corresponding to 1500 Hz and black to 2300 Hz.

circuit description

The complete circuit of the facsimile transmitting converter appears in **fig. 3**, and its various parts are analyzed below.

Rectifier and video filter. A small input transformer, T1, isolates the converter from the facsimile apparatus; it can be omitted if the units have a common ground potential. A precision half-wave rectifier is built around amplifier U1A. The negative half-periods of the a-m signal are presented with reversed sign across R4 at the summing point of the amplifier U1B, where the original signal is added through R5 and R6; balanced full-wave rectification occurs by adjustment of R6.

The video voltage is separated from the carrier by an active filter of third-order Darlington response, consisting of a simple lag circuit, U1B, and a Sallen-and-Key lowpass circuit, U1D, with an added high-pass path, U1C, to insert a notch at twice the carrier

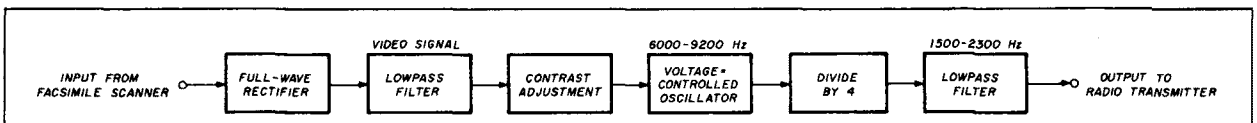


fig. 2. Block diagram of alternative facsimile transmitting converter.

frequency (3600 Hz). The filter was built with readily available plastic-film capacitors of 2.5 percent tolerance and metal-film resistors of the E48 series having 1 percent tolerance. **Fig. 4** shows the response of the video filter.

The video signal is delivered negative with respect to ground; it can be measured at test point TP1. The input potentiometer, R1, is set to yield approximately −2.5 volts at TP1 for maximum input signal. Due to amplifier offset, an output is likely to be present at

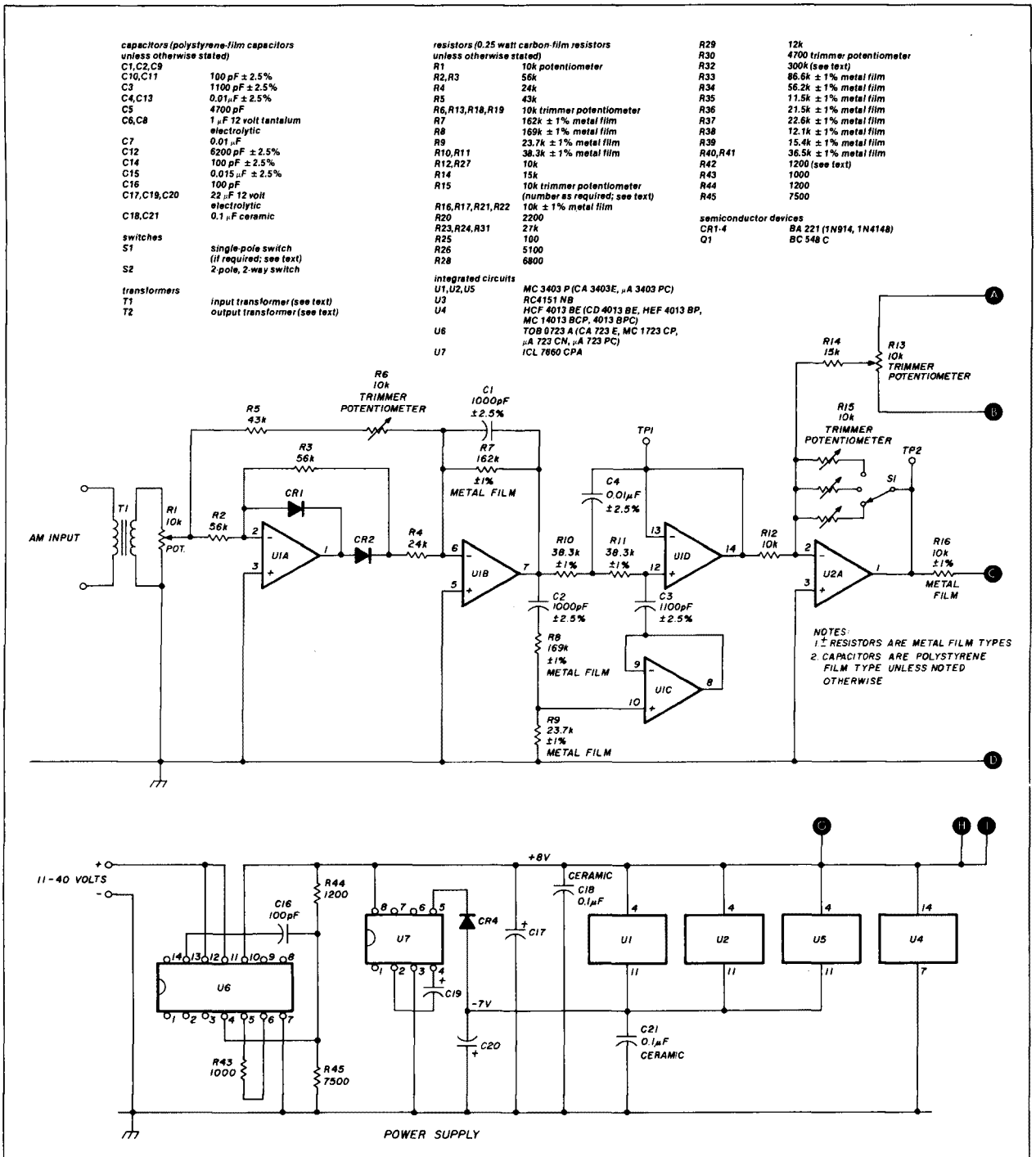


fig. 3. Circuit diagram of facsimile transmitting converter.

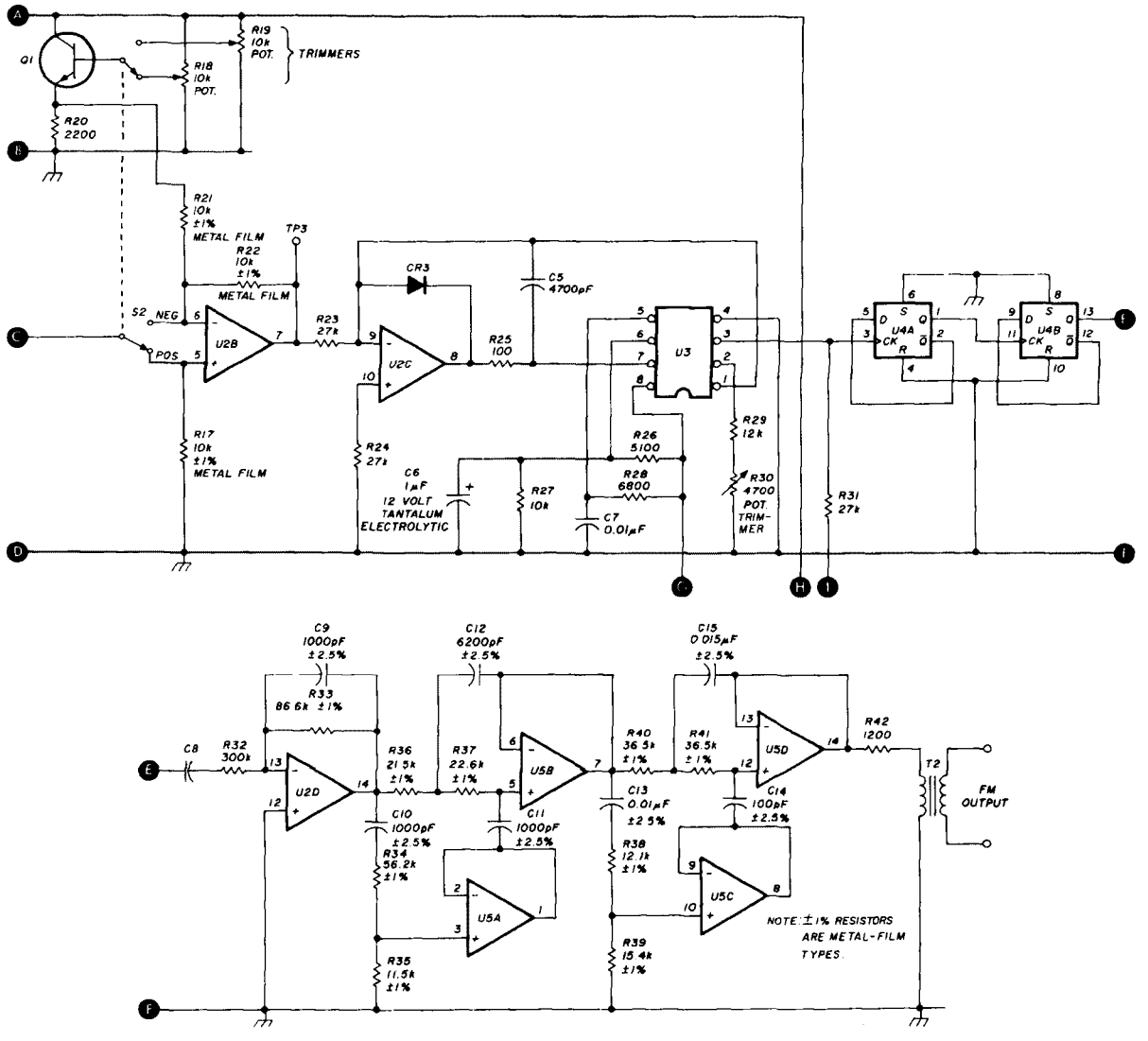


fig. 3. Circuit diagram of facsimile transmitting converter (continued).

TP1 for zero-input signal; this error will be eliminated in contrast adjustment.

Contrast adjustment. Video contrast, which may be positive or negative and of arbitrary magnitude (to about 30 dB), is adjusted in a two-stage dc processor (U2A, U2B), shown in simplified form in **fig. 5**.

In the first stage, a constant voltage, u_0, is added to the video signal, u_1, so that zero output is produced at test point TP2 when the a-m facsimile signal is set to its nominal maximum amplitude. The stage gain (A, determined by the resistance ratio of R15 to R12) is adjusted to obtain −800 mV at TP2 when the input a-m signal is reduced by the nominal contrast. If the converter is to be used with several different facsimile scanners, any relevant number of contrast-setting resistors (R15) may be used; the actual contrast is selectable by switch S1.

The second stage is used as a summing or subtracting amplifier. Resistors R16, R17, R21, and R22 have a 1 percent tolerance. For an a-m facsimile input of positive contrast, a further constant voltage ($u_L = 1500\ mV$) is subtracted from the signal to yield at test point TP3:

$$u_2 = -u_L - A(u_1 + u_0) \quad (1)$$

where A is the stage gain of the first stage (U2A). Observing the negative sign of u_1, we find $u_2 = -1500\ mV$ for a maximum (white) and $u_2 = -2300\ mV$ for a minimum (black) input signal. For an input of negative contrast, the sign of the video signal is reversed, and a constant voltage $(u_H = 2300\ mV)$ subtracted so that, at TP3,

$$u_2 \approx -u_H + A(u_1 + u_0) \qquad (2)$$

Thus, $u_2 = -2300\ mV$ for maximum (black) and $u_2 = -1500\ mV$ for minimum (white) signal.

Transistor Q1 provides a low-impedance source for the voltage fed to R21; otherwise the source impedance would affect the stage gain of U2B in transmission with positive contrast.

Those who wish to transmit facsimile by direct frequency modulation of the transmitter's carrier oscillator may use the adjusted video signal at TP3 as the input.

Voltage-controlled oscillator. The heart of the oscillator is U3, a monolithic IC comprising a comparator, single-shot multivibrator, and a gated precision current source with an internal voltage reference. The device is manufactured by Raytheon. Besides the original version RC (RM, RV) 4151, an improved version, the RC 4152, has been announced; the latter was not, however, available to me.

The negative video voltage at TP3 is summed with positive-charge pulses from pin 1 of U3 into an integrator, U2C. The integrator output is fed into the comparator at pin 7 of U3, thus controlling the multivibrator. The pulse-repetition frequency will settle so that the average value of the current at pin 1 will equal the current due to video input. The magnitude of the charge pulses is determined by R29 and R30, which set the oscillator's voltage-to-frequency conversion factor.

Having a duty cycle that varies with frequency, the pulse train produced by U3 is passed to the two-

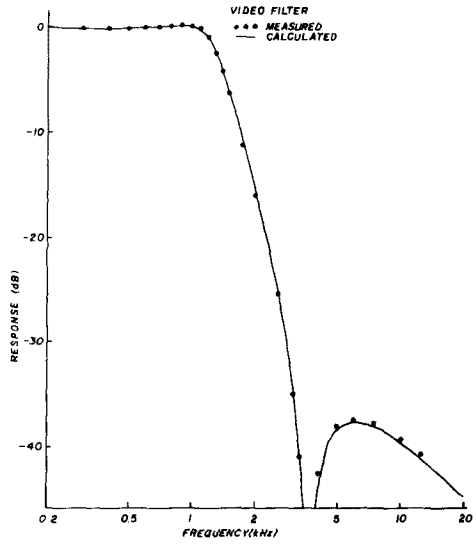


fig. 4. Calculated (solid line) and measured (dots) characteristic of video filter. The carrier-suppression notch was measured at −50 dB at 3618 Hz.

stage flip-flop, U4, which provides a symmetrical square-wave train at one-fourth the original pulse-repetition rate. The overall conversion factor is chosen to be 1 Hz/mV, that is, the limits 1500 and 2300 mV of the adjusted video voltage will correspond to 1500 and 2300 Hz respectively in the square-wave output.

No measure for offset compensation of U2C was found necessary.

Output filter. The square-wave train from U4 can be resolved into odd harmonics of its fundamental frequency, which implies that it can be changed into a sinusoidal signal by a filter that suppresses all components of frequency above three times the lowest

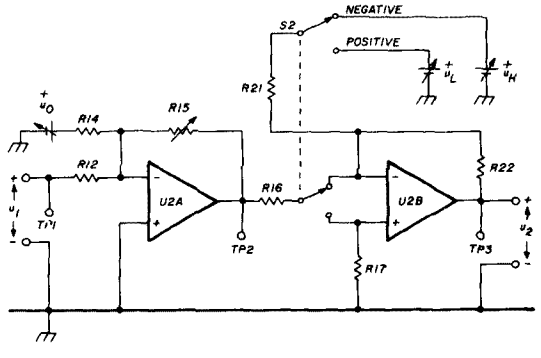


fig. 5. Processing of video signal. Switch S2 selects between positive and negitive contrast of the input a-m signal.

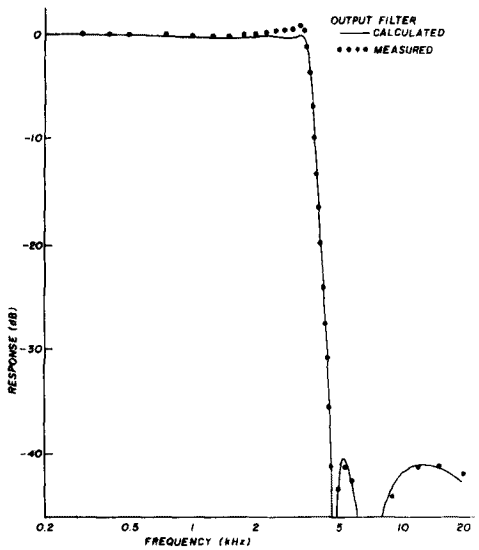


fig. 6. Calculated (solid line) and measured (dots) characteristic of output filter. The notches were measured at 4765 Hz and 6960 Hz.

carrier frequency used; that is, above 4500 Hz. On the other hand, this filter must pass the entire spectrum of interest — for a maximum carrier frequency of 2300 Hz and a maximum video frequency of 750 Hz, the filter cutoff frequency should not occur below

$$2300\,Hz + 1.6 \times 750\,Hz = 3500\,Hz$$

To achieve such steep cutoff, the filter was given a fifth-order Darlington response. A simple lag circuit, U2D, is followed by two cascaded Sallen-and-Key stages, U5B and U5D, with additional highpass paths, U5A and U5C respectively. Thus, notches are produced at 7010 Hz and 4760 Hz respectively, yielding attenuation in excess of 40 dB above 4400 Hz and still keeping the passband attenuation below 1 dB up to 3400 Hz (**fig. 6**). The filter was implemented with 2.5 percent plastic-film capacitors and 1 percent metal-film resistors.

The final stage, U5D, is coupled to the transmitter through a small transformer, T2, if required; otherwise capacitive coupling may be used. Resistor R42 was included to provide a matched 600-ohm output at T2; it may be omitted. The level of the output fm signal may be adjusted by changing the resistance of R32.

Power supply. The converter operates from a negative-ground dc source of 12 volts nominal. For the contrast adjustment and voltage-controlled oscillator to work unaffected by any supply-voltage variations, a *regulated* supply is provided at 8.25 volts; the voltage regulator, U6, is internally compensated for temperature drift. In addition, the operational amplifiers require a negative supply of −7.25 volts, which is furnished by a monolithic voltage inverter, U7. This device is a type ICL 7660 by Datel Intersil.

Proper operation occurs over the input-voltage range of 10.5 — 40 volts; current consumption is 25 mA throughout this range.

construction notes

The prototype converter was built on a 3.7 by 4.3-inch (95 by 110 mm) piece of perf board, but the design *can be readily transferred to an etched circuit* board. In a definitive design, the simple carbon trimmer potentiometers used with the prototype will be replaced by multi-turn Cermet trimmers.

alignment procedure

The instruments required for alignment of the facsimile converter comprise a dc voltmeter, a cathode-ray oscilloscope and, preferably, a frequency counter. Moreover, a sine-wave signal source is necessary; this may be the facsimile scanner.

Alignment is carried out as follows:

1. With a low-frequency (50-Hz) sinusoidal signal applied to the converter input, R6 is adjusted to produce a symmetrical full-wave-rectified output signal at test point TP1, as shown on the oscilloscope screen.

2. A signal at the nominal carrier frequency (1800 Hz) and the nominal maximum level (775 mV) is fed into the converter. R1 is set to yield approximately −2.5 volts at TP1. Then R13 is adjusted for zero voltage at TP2.

3. The input signal level is reduced by the nominal contrast (typically 8-30 dB), and R15 is adjusted to obtain −800 mV at TP2. If the converter is to be used with several contrast settings, this procedure is repeated for each position of S1.

4. The input signal is removed and TP2 is shorted to ground. With S2 set at position POSITIVE, R18 is set for −1500 mV at TP3, and with S2 at NEGATIVE, R19 is set for −2300 mV at TP3.

5. With −2300 mV at TP3 (S2 at NEGATIVE), R30 is adjusted for a frequency of 2300 Hz measured at the converter output. With −1500 mV at TP3 (S2 switched to POSITIVE), the frequency should then read 1500 Hz. The short at TP2 is removed.

The converter is now ready for use.

performance

Factors of importance to the converter's functioning are the responses of the filters and the linearity of

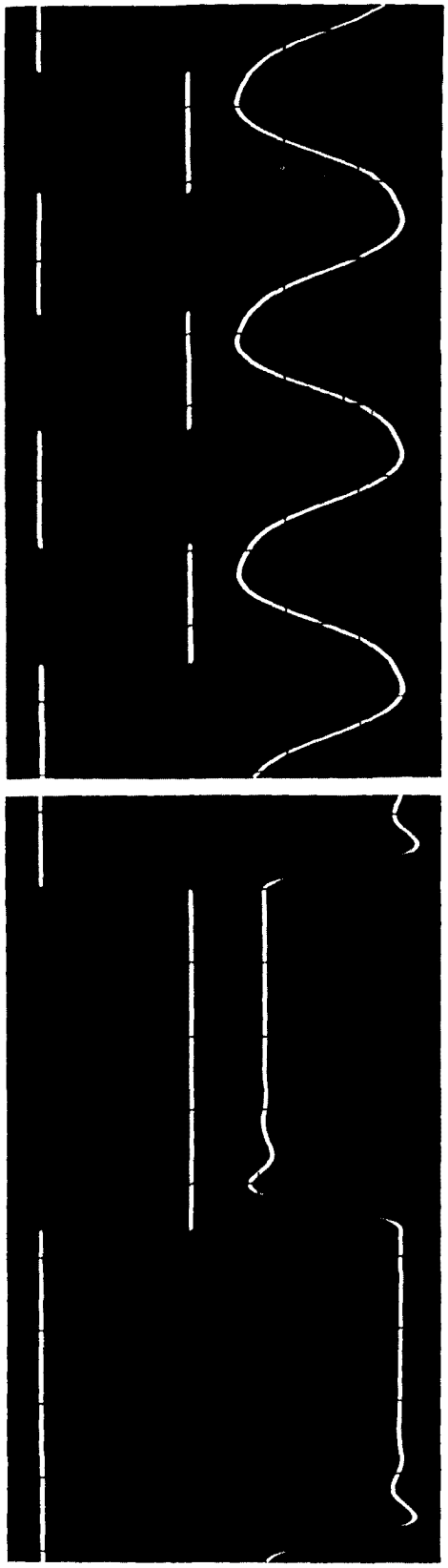


fig. 7. Square-wave response of video filter at 100 Hz (left) and 622 Hz (right).

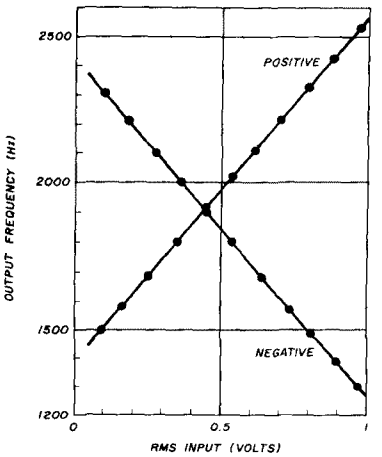


fig. 8. Plots of the output frequency versus RMS input voltage at 1800 Hz for both positions of S2 with converter adjusted for 18-dB input contrast.

the voltage-controlled oscillator.

The measured characteristic of the video filter was found to closely reproduce the calculated behavior (**fig. 4**). Its step response (**fig. 7**, left) shows 340 μs rise time, about 12 percent overshoot and a slight oscillation of 400 μs half-period. The smallest picture element to be resolved in a facsimile transmission with $M = 264$ and 90 scanning strokes per minute, having a duration of some 804 μs (corresponding to a 622 Hz square-wave train), is well rendered by the filter (**fig. 7**, right).

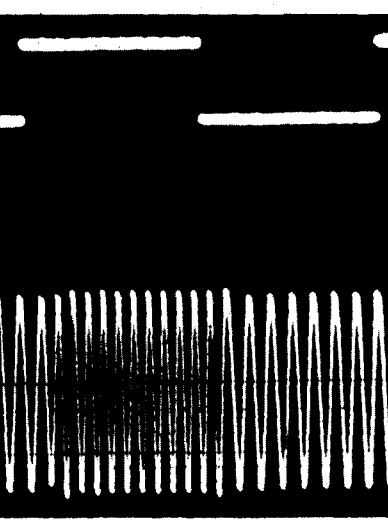


fig. 9. Output signal of 1500 Hz and 2300 Hz (bottom) produced by 100-Hz square-wave train (top) applied to input of video filter.

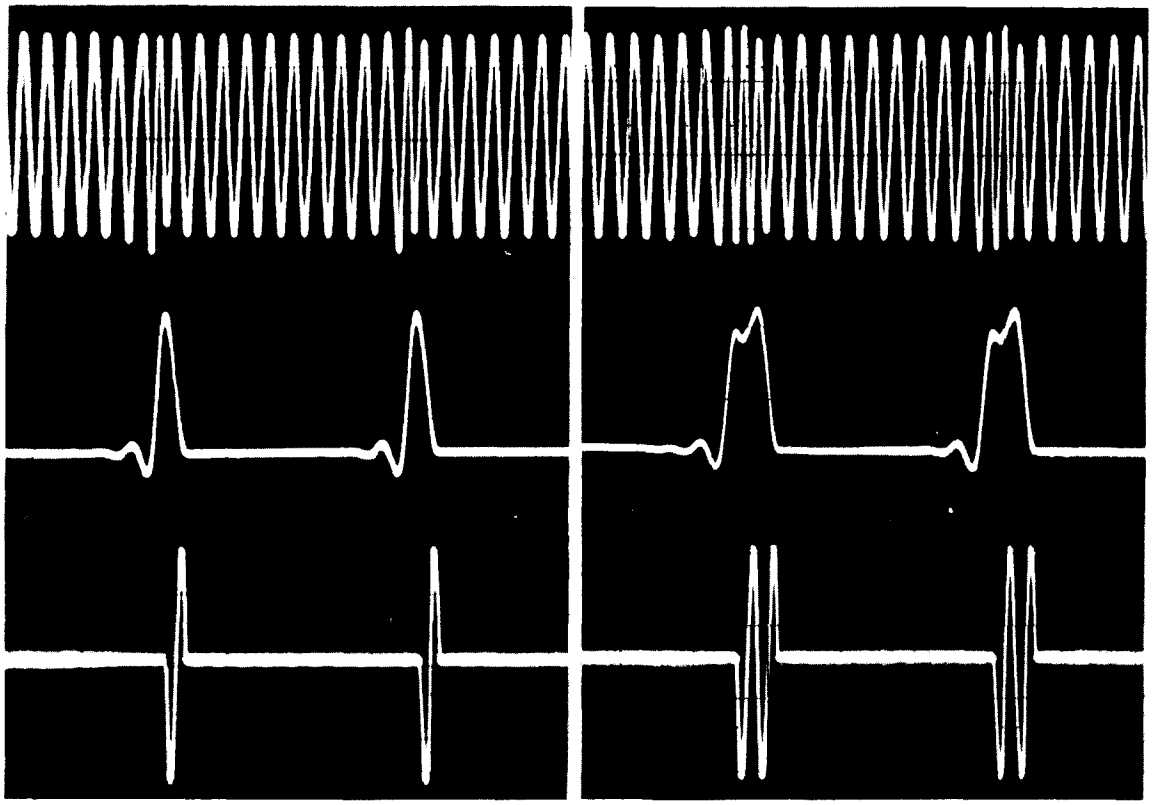


fig. 10. Overall response (bottom) to burst-modulated 1800-Hz sine wave (top) applied to converter input, producing at TP3 a video signal (center) alternating between −1500 mV and −2300 mV. Burst duration 1100 μs (left) and 555 μs (right).

No deviation from linearity could be observed between input voltage and output frequency (**fig. 8**). With TP3 shorted to ground, the frequency of oscillation was measured to 5.7 Hz at pin 3 of U3, confirming that any offset adjustment of the oscillator could be omitted.

The output filter showed a slightly elevated response in the passband near cutoff (**fig. 6**) as compared to its calculated performance. This was due to tolerances of the filter components, especially the capacitors, and resulted in a 3 percent (0.3 dB) increase in output amplitude from 1500 Hz to 2300 Hz. However, in view of the baseband response of the transmitter to be used, no correcting measures were taken.

The overall response of the converter (**figs. 9** and **10**) is sufficient to reproduce the 800-μs bursts representing the smallest picture elements. For abrupt changes in input level, a slight overshoot occurs in the output envelope; the observed 7 percent (0.6 dB) fluctuation is smaller than will be seen with certain teleprinter audio-frequency-shift keyers.[7]

The rms output signal at pin 14 of U5D amounts to 1.0 volt. The signal magnitude may be altered by a change of R32, the output amplitude varying inversely with resistance.

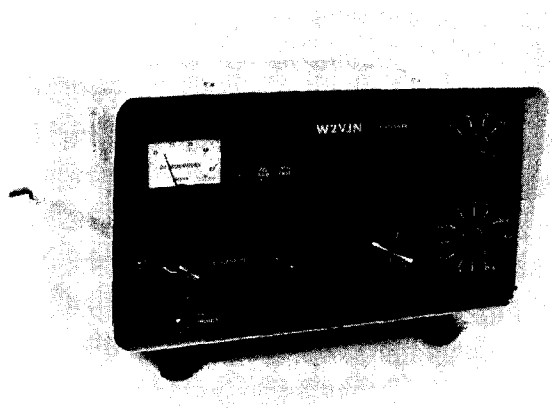
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ham radio

part two:
audio and AGC
board, synthesizer,
and power supply

up-conversion receiver for the high-frequency bands



This receiver is designed as a group of modules and boards. Front panel reflects clean layout and operator convenience.

author's note
The object of this two-part construction project is strictly educational. I wanted to see if it was possible to produce a fairly good unit with readily available parts and, if so, to go on to design and construct a transceiver. Because of this, the module construction was done in breadboard fashion. There are no board layouts available, but some of the photos show typical construction techniques used throughout.

Last month, in part one of this two-part article, I described the basic design of my up-conversion receiver, then went on to discuss the mixer stages, i-f filter, and BFO. This month, in part two, I will complete my discussion of the up-conversion high-frequency receiver, beginning with the audio and AGC board.

audio and AGC board

The product-detector output is terminated in 51 ohms on the audio board and drives both the audio output circuitry and the AGC circuitry as shown in **fig. 10**. A two-pole Butterworth lowpass active filter provides 20 dB gain and reduces the wideband noise from the i-f output. A summing amplifier provides an auxiliary audio input for CW sidetone or a DX spotting net receiver. Power gain is provided by an LM380. A few additional dB of negative feedback is used to reduce the LM380 hiss and distortion to a negligible level. The over-all audio gain is 48 dB maximum. The bandwidth is 150-2400 Hz. Total harmonic distortion is better than −60 dB at 0.8 watt output.

The AGC is an audio-driven hang-type system. Much time was spent deciding what arrangement to

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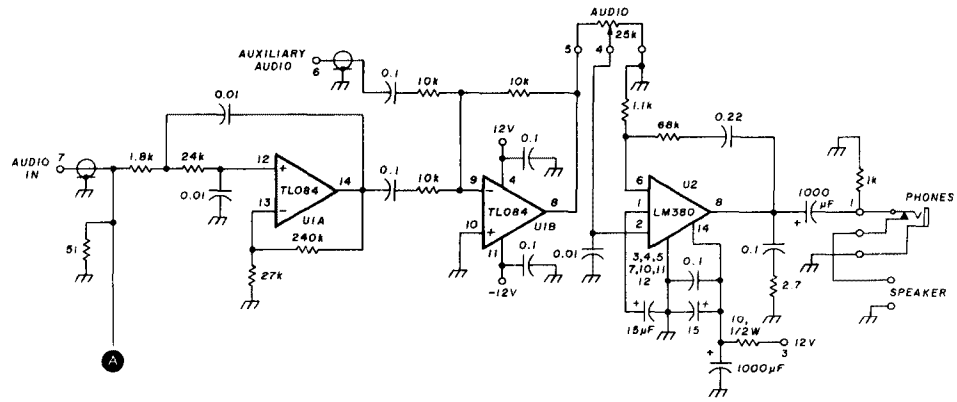


fig. 10-1. Audio and AGC schematic (B3 board).

use, because much of the "operating character" of the receiver stems from its AGC system. One need only to listen to some of the modern transceivers to note that an otherwise adequate receiver can be almost ruined by poor AGC system design.

The hang-AGC system allows the decay time constant to be set very long to eliminate overshoot on strong CW signals. Many tests were run, and I found that an attack time faster than 10 milliseconds would result in the receiver responding too readily to single noise spikes, such as those produced by oil burners and wall switches. Of course, if the attack time constant is too long, each transition from weaker to stronger is accompanied by a large overshoot. The required attack time is easily obtained at audio frequencies rather than at i-f, and the resulting circuitry is easy to implement and is noncritical. For a step input of no signal to one millivolt, this receiver overshoots less than 2 dB. There is no overshoot on dots and dashes of a CW signal after the initial acquisition. It sounds quite smooth on SSB and CW.

The gain of op amp U3A determines the normal operating level in the product detector. This is because the minimum signal that will create AGC voltage has a peak voltage just adequate to overcome the drop in the IN914 rectifier. For the AGC threshold, the level at the product detector input is −17 dBm. The attack time is controlled by the 1k resistor. The gain of U3B is set so that the 2N5640 FET is biased off for the signals that would normally activate the AGC. When the signal drops in level or disappears, the 2N5640 turns on and rapidly discharges the AGC capacitor through a 100k resistor. The hold time is determined by the 15 µF capacitor in the 2N5640 gate circuit. The AGC switch allows for selection of 0.3 second or 0.7 second. U3C provides the offset voltage required by the MC1590 i-f amplifiers. The gain of the U3C circuit is held low to provide a slope of about 7 dB to the over-all AGC characteristic. Control voltage for the front-end attenuator is supplied by U3D. The threshold adjustment is normally set for 100 microvolts.

synthesizer

The synthesizer locks a 45- to 75-MHz VCO to a 5.05-5.55-MHz VFO in 0.5-MHz bands, as selected by an offset crystal oscillator. The offset signal could also be synthesized, but in the interest of simplicity and minimizing spurious outputs, a crystal oscillator was chosen.

45-75 MHz VCO. This VCO uses a grounded-gate U310 FET in the Colpitts configuration. See fig. 11. One of four ranges may be selected by applying 8 volts to a range-select input. PIN diodes are used to minimize stray capacitance. Tuning is accomplished by an MV104 varactor. The varactor is returned to −8 volts, and the normal range of the tuning voltage is ±5 volts. The coils are adjusted so that the maximum of each range is the fourth root of the over-all ratio times the minimum frequency; *that is,*

$$range\ 1\ max = \sqrt[4]{\frac{75}{45}} \times 45 = 51.13\ MHz \quad (1)$$

$$range\ 2\ max = \sqrt[4]{\frac{75}{45}} \times 51.13 = 58.09\ MHz \quad (2)$$

$$range\ 3\ max = \sqrt[4]{\frac{75}{45}} \times 58.09 = 66.01\ MHz \quad (3)$$

$$range\ 4\ max = \sqrt[4]{\frac{75}{45}} \times 66.01 = 75.00\ MHz \quad (4)$$

The purpose of range selection is to improve oscillator stability and to minimize the VCO gain constant for reducing phase noise. The VCO range is selected by a diode matrix on the crystal-oscillator board.

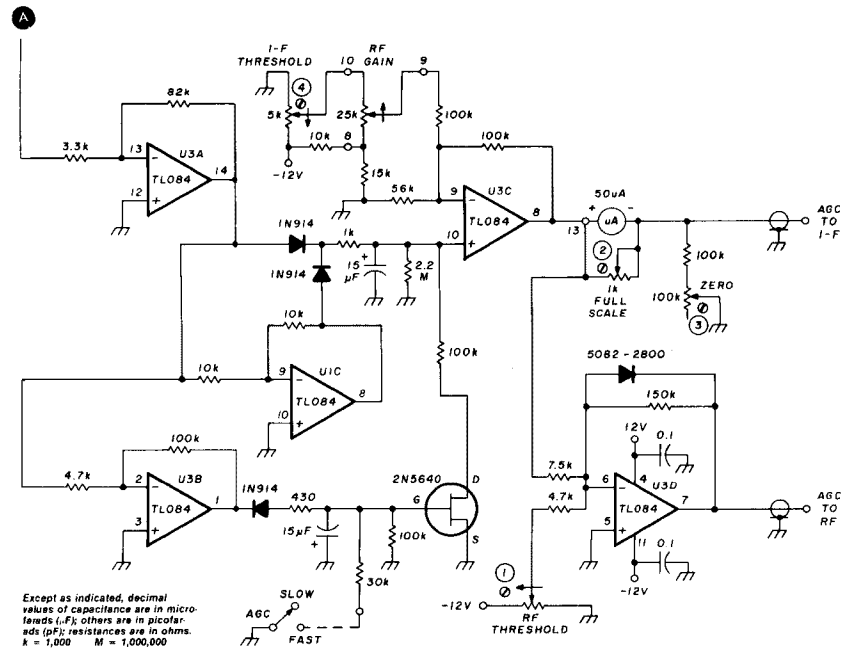


fig. 10-2. Audio and AGC schematic (B3 board), continued from previous page.

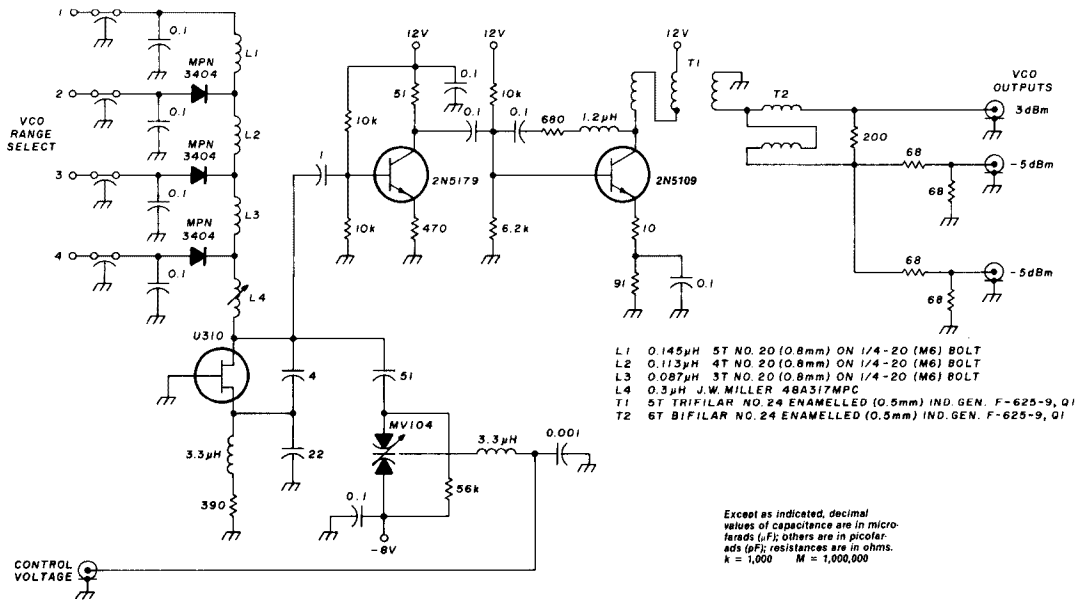


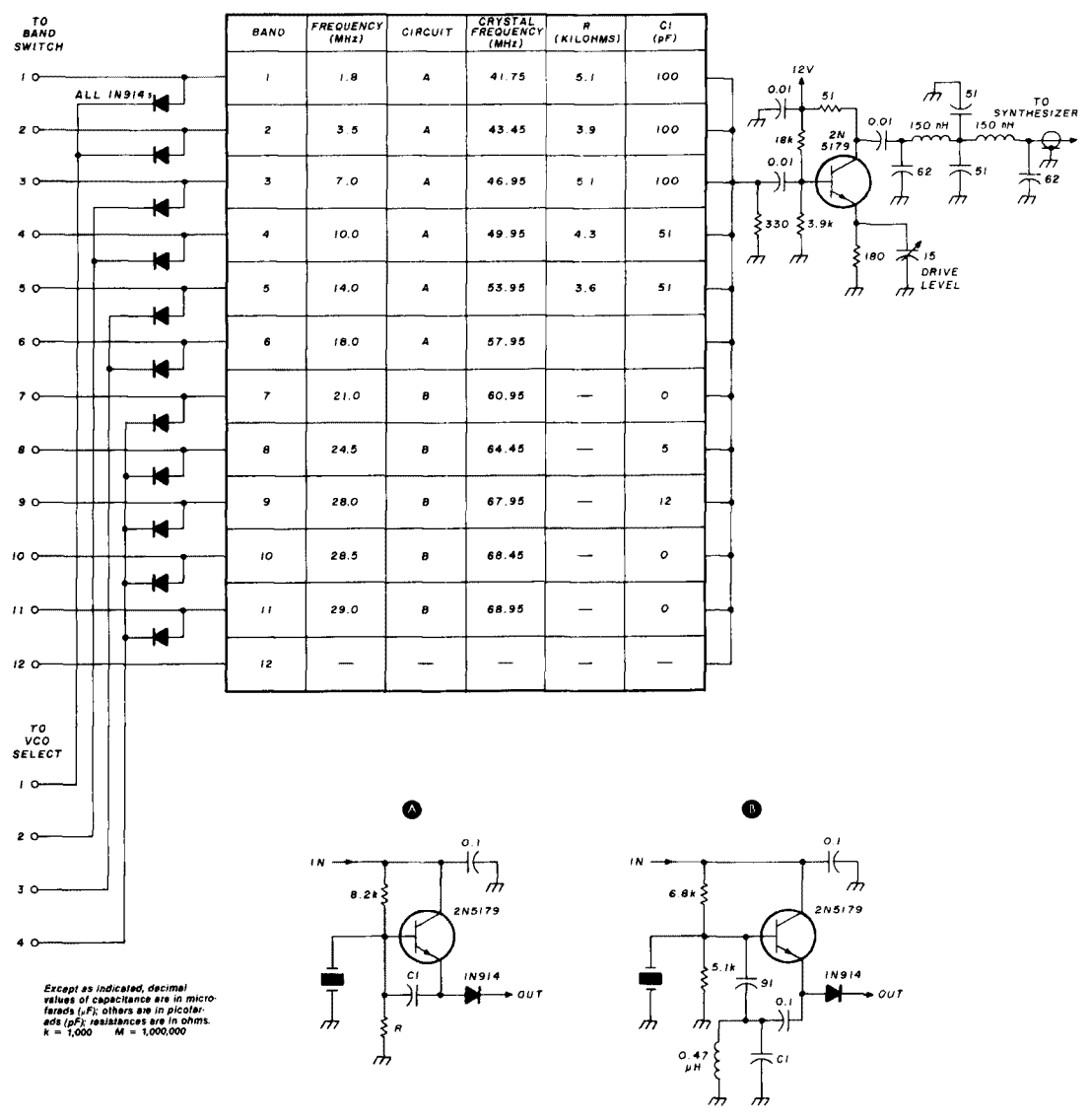
fig. 11. 45 to 75-MHz VCO schematic (part of M7 module). Unit uses a grounded-gate U310 FET in a Colpitts circuit. One of four ranges may be selected by applying 8 volts to a range-select input. Tuning is by an MV104 varactor.

A 2N5179 isolation amplifier couples a small amount of VCO output power to a 2N5109 power amplifier. This amplifier drives a two-way power divider. One output goes to the first mixer module at a 3-dBm level. The other output is split to provide synthesizer feedback to drive the display module.

Crystal oscillator. Twelve crystal oscillators are used to select 12 bands. The limitation is in the switch itself, although twelve bands are more than adequate for my use. The receiver frequency coverage is shown in **fig. 12**. With this arrangement, all currently available bands are covered except for the top 200 kHz of the 10-meter band. Also, the three new bands are covered, and one spare (12) remains unused. The oscillator in use is selected by an 8-volt level from the bandswitch.

Two types of oscillator circuit are used: the A type is for third-overtone and the B type is for fifth-overtone crystals (**fig. 12**). These circuits are very simple, and the price paid for this simplicity is that a certain amount of adjusting must be made with component values for reliable operation.

Each oscillator is adjusted to start and operate on the correct overtone, to remain there for B+ varia-



BAND	FREQUENCY (MHz)	CIRCUIT	CRYSTAL FREQUENCY (MHz)	R (KILOHMS)	C1 (pF)
1	1.8	A	41.75	5.1	100
2	3.5	A	43.45	3.9	100
3	7.0	A	46.95	5.1	100
4	10.0	A	49.95	4.3	51
5	14.0	A	53.95	3.6	51
6	18.0	A	57.95		
7	21.0	B	60.95	—	0
8	24.5	B	64.45	—	5
9	28.0	B	67.95	—	12
10	28.5	B	68.45	—	0
11	29.0	B	68.95	—	0
12	—	—	—	—	—

fig. 12. Crystal-oscillator schematic (B5 board). Twelve oscillators are used to select 12 bands. Two types of oscillator circuit are used. Circuit in A is for third-overtone and that in B is for fifth-overtone crystals. Receiver frequency coverage is shown in the table.

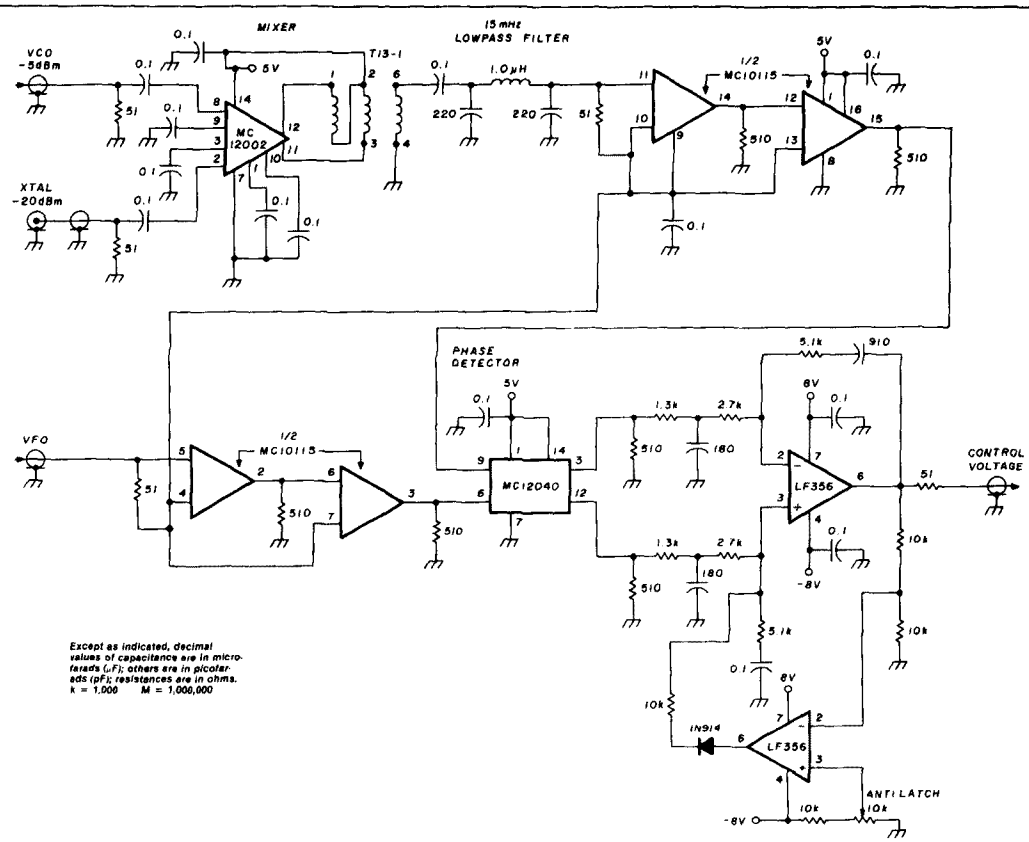


fig. 13. Phase-detector schematic (part of M7 module). VCO and crystal-oscillator outputs are mixed in an MC12002 IC. The two square waves representing the difference sideband signal are processed by an MC12040 phase and frequency detector. The LF356 IC operates as a differential loop filter.

tions of ±2 volts, and to provide approximately the same drive level out of the module. It's not important that each oscillator be exactly on frequency, since the digital readout provides the receiver frequency accuracy. These frequencies vary about ±1 kHz in my receiver.

A 2N5179 isolation amplifier drives a lowpass filter through a 50-ohm line to the synthesizer module. A 15-pF trimmer capacitor tips the frequency response to help keep a constant drive level across the 40- to 70-MHz band.

Phase detector. The VCO and crystal outputs are mixed in an MC12002 double-balanced modulator IC. See **fig. 13**. A lowpass filter selects the difference sideband signal, and one-half of a MECL comparator (MC10115) changes it to a square wave. Another half of the MECL comparator squares up the VFO output, and the two square waves are then processed by an MC12040 phase and frequency detector. This unit is functionally identical to the MC4044 but it is an MECL implementation and is usable to 80 MHz. Also, at any frequency, it provides less random jitter due to differential propagation delays between input and output. The MC12040 output drives a differential loop filter using an LF356. Some attenuation of the sampling frequency spikes is provided by the 180 pF capacitors in the loop filter.

The normal VCO operation voltage range is ±5 volts. Under some conditions the VCO output can go below the crystal frequency. When this occurs, the feedback sense shifts to positive, and the loop will latch up with the VCO drive voltage at the negative rail. A second LF356 senses this condition, and jams the loop to a normal lock.

5-MHz VFO. This VFO uses a 2N5397 FET in the Vackar configuration, as shown in **fig. 14**. A surplus BC221 tuning capacitor is the main tuning element. I used it because of the high-quality worm drive that comes with it. The over-all tuning rate is about 14 kHz per knob revolution.

The output is taken through the capacitive tap across the tuned circuit. This method gives a good sine wave because of the high circuit *Q*. Two isolation stages buffer the output.

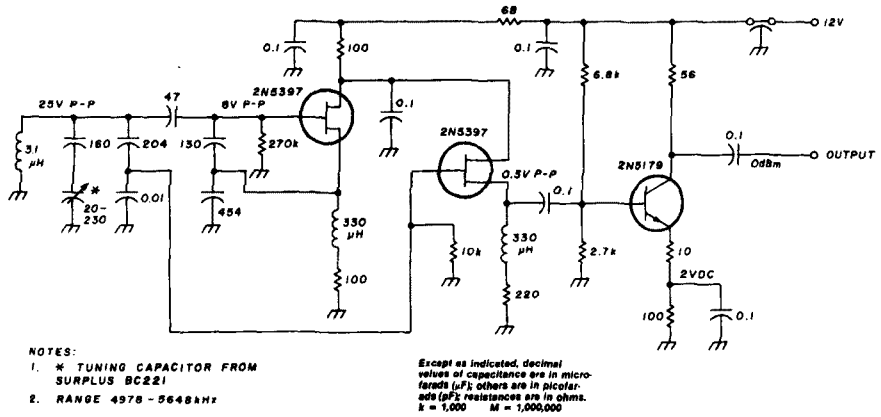


fig. 14. 5-MHZ VFO (part of M7 module). A 2N5397 Vackar oscillator is used in this circuit. High circuit *Q* provides a good sine wave. Two isolation stages buffer the output.

The VFO has been very satisfactory in operation; however, I could have used heavier material than a minibox, because a shift of 100 Hz is noticeable if the receiver is turned upside down while listening to a CW signal. Flexing of the tuned circuit components causes this problem.

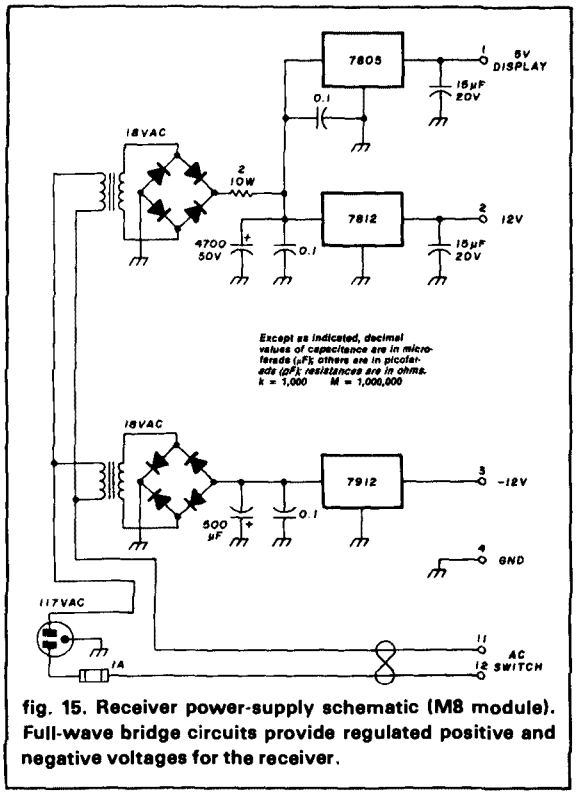


fig. 15. Receiver power-supply schematic (M8 module). Full-wave bridge circuits provide regulated positive and negative voltages for the receiver.

The short-term stability characteristics of this oscillator determine the over-all receiver performance. Therefore, high-*Q* components should be used in the oscillator tank circuit.

power supply

The power supply module schematic is shown in **fig. 15**, and the wiring diagram of the receiver in **fig. 16**.

display module

A six-digit counter displays receiver frequency. The counter is preset to minus 450,000 counts to subtract the first i-f from the displayed value. The counter then counts the synthesizer frequency but displays the signal frequency. A 10-MHz clock generates the count gate. This oscillator can be set to zero beat with WWV to calibrate the display. The schematic is shown in **fig. 17**.

construction

The receiver is designed as a group of modules and boards with 50-ohm interfaces. This design allows for flexibility during the construction phase; several of the modules were modified or reconstructed in some way. This receiver is strictly a breadboard unit, although it's easy to work on and is fairly sturdy from an electrical and mechanical viewpoint. Many of the modules are fastened to the sides of the frame and are easily removable. The sides may be unscrewed to gain access to the inner portions of the receiver; yet, the unit is operational in this condition. Some of the boards are fastened under the main deck and covered by shield cans. Module and board layouts are shown in the photos.

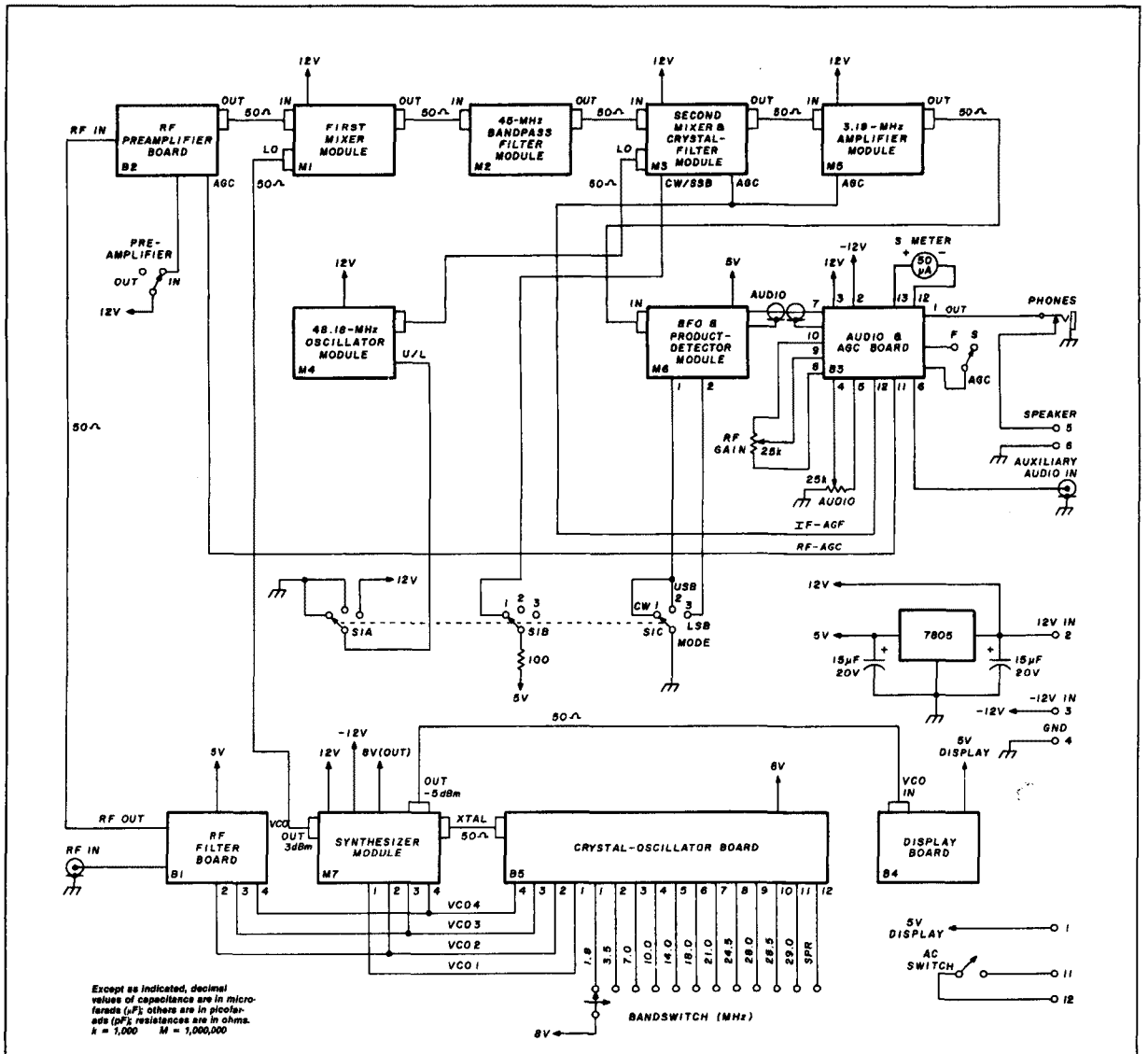


fig. 16. Interconnection diagram. The receiver is designed as a group of modules and boards with 50-ohm interfaces.

Several board construction techniques are used. The rf circuitry is built onto blank printed-circuit material. Miniature terminal strips are soldered to the boards, and the components are mounted on the strips. This method requires no hole drilling except for the four mounting holes. The audio-AGC board is built on a VERO™ card, and the display module uses wire wrap. All boards have ground planes and use extensive bypassing.

All parts are readily available through mail-order houses. Suitable and equivalent SSB and CW filters are available from Fox-Tango Corp. The PTI and Minicircuits™ components may be purchased direct. Although an account was not kept, the cost was of the order of several hundred dollars for the receiver.

in conclusion

Was it worth the effort? Yes! I learned a great deal. I now have the feeling that a *good* transceiver can be built for about half the price of available units.

As for improvements, a few came to mind: There should be more filtering at the 5-MHz sampling frequency. The switching sidebands are only down 80 to 85 dB. This is not sufficient with an open front-end design. The VCO and VFO should have better har-

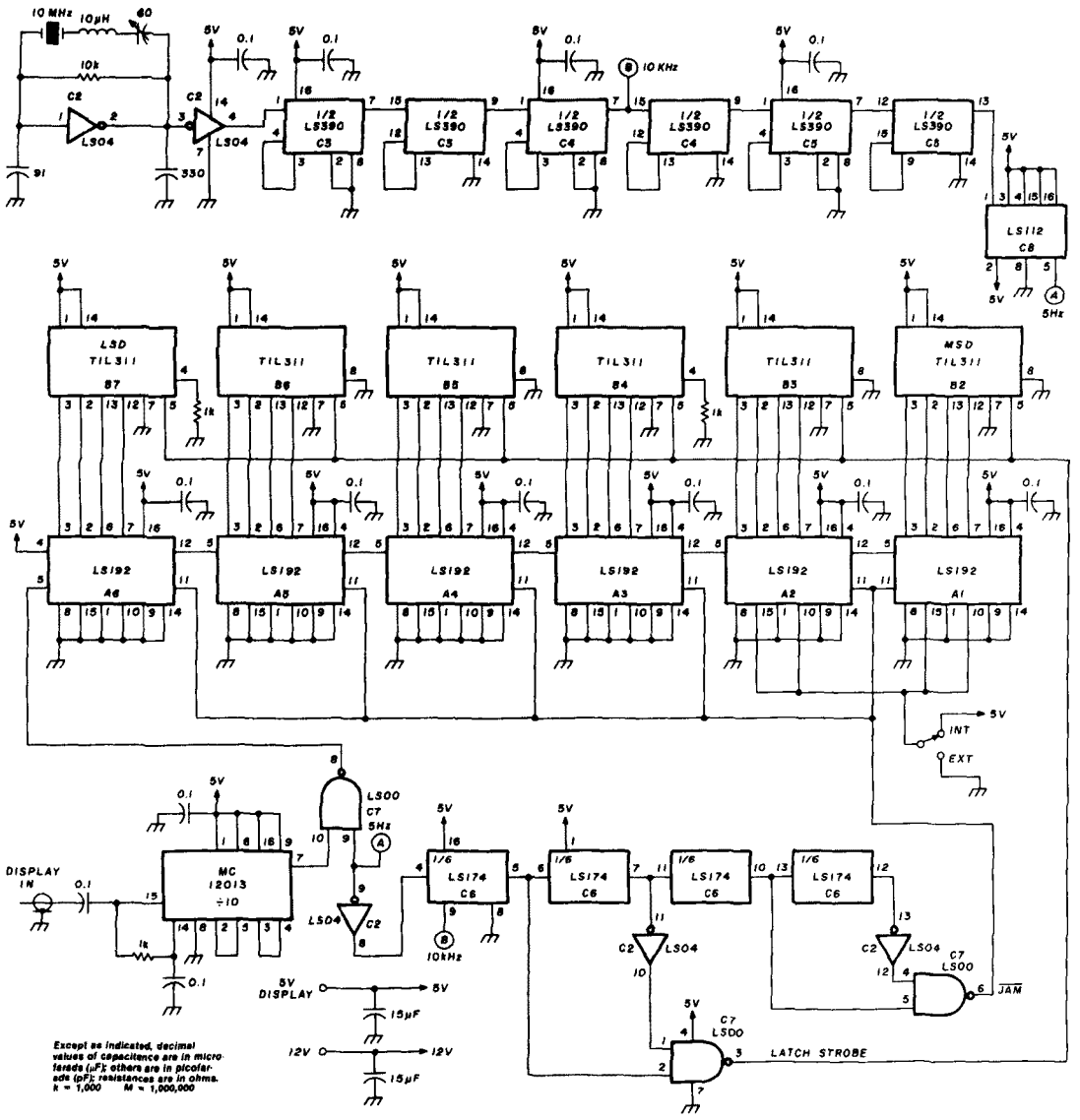


fig. 17. Display-board schematic (B4 board). A six-digit counter displays receiver frequency.

monic filtering, which will eliminate the VFO fourth harmonic response from appearing at 21.2667 MHz as well as other spurious signals.

The VFO and synthesizer should be mounted in separate shielded boxes. Tank-circuit voltage in the VFO is quite high, and this field contributes to the filtering problem. Space should be allowed for more 3.18-MHz crystal filters for operating flexibility.

acknowledgments

Credit is due to WB2DGJ, KB2NJ, and WA2QAF for helping with the construction, and to WA2IFG (my XYL) and Grace (my secretary) for helping with the typing. Pictures were furnished by W2PJK.

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ham radio

ham radio TECHNIQUES

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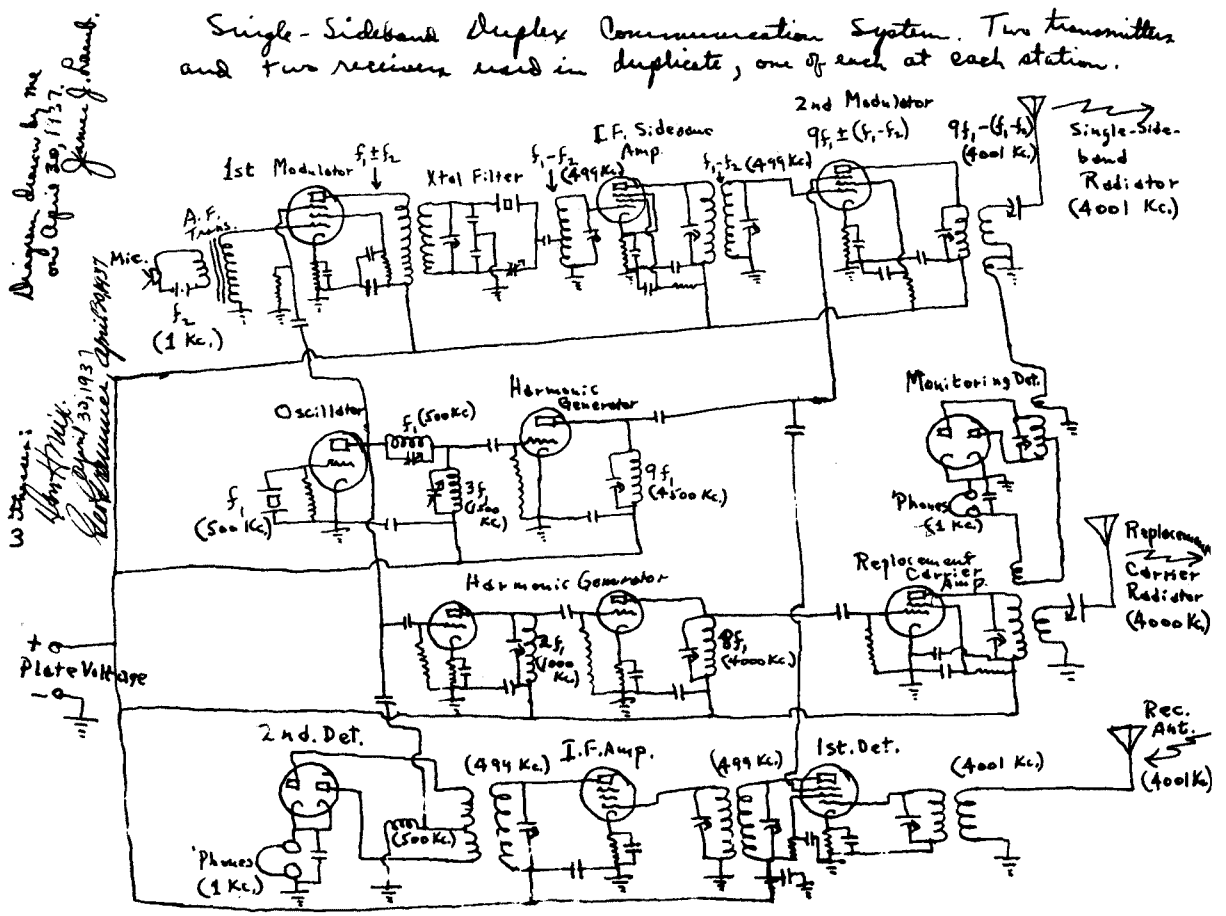


fig. 1. Schematic of the proposed single-sideband transceiver, April 30, 1937. World's first SSB transceiver was designed by Jim Lamb, W1AL, then Technical Director of *QST* magazine. While the concept was feasible, it was never discussed in *QST* because it was "too complicated *for* the average Amateur." The idea lay dormant for twenty years until Collins Radio Co. developed the famous KWM-1 transceiver. Jim's transceiver was designed to work in the 80-meter band on USB. Judging those days from these days, it looks as if the idea would have worked. The weak link was the sideband filter shown, which could not reject the complete unwanted sideband. Note that a "replacement carrier" was radiated by a separate antenna. Witnesses signed the sketch on the left margin: George Grammar and Don Mix, both well-known communications engineers.

The single-sideband transceiver is the standard "black box" of the modern station. Was there a time when Amateurs were without this popular means of communicating?

Old-timers can recall the days of the mid-fifties when SSB was new and exciting. In 1957, the Collins Radio Company introduced the KWM-1 SSB transceiver; Herb Johnson, W6QKI, was hard at work designing the prototype of the famous Swan series of transceivers.

But the concept of the SSB transceiver was actually developed in the spring of 1937! For twenty years the idea had lain dormant. War, and the lack of suitable sideband filters and stable oscillators, put SSB on the back burner for all except a few experimenters who toyed with this exotic form of communications.

Nevertheless, the basic idea for the SSB *transceiver came about* in April, 1937, when James J. Lamb, W1AL, then the Technical Editor of *QST*, completed the design of a "single-sideband duplex communication system" and had his sketch witnessed for posterity (fig. 1).

Jim's novel transceiver worked in the 80-meter Amateur band on a fixed frequency (4.000 MHz). A block diagram is shown in fig. 2. This clever design anticipated frequency synthesis decades before its time. The transmitter portion of the transceiver is at the top of the sketch. Starting, for example, with an audio tone of 1 kHz, the signal is amplified and mixed with a 500-kHz carrier from a crystal oscillator. The sum and difference frequencies (499 kHz and 501 kHz) are passed through a crystal filter, which passes the lower (difference) sideband of 499 kHz and rejects the 501-kHz signal. The wanted signal is amplified in a 500-kHz passband amplifier and fed to a mixer for conversion.

The mixer injection signal is at 4.5 MHz and is derived from the ninth harmonic of the 500-kHz oscillator by virtue of a times-nine multiplier, or harmonic generator. The resulting signal is upper sideband, with the 1-kHz tone at 4.001 kHz.

Jim Lamb added a "replacement carrier" generator to supply a carrier at 4.000 kHz. Note that the carrier was radiated by a separate antenna. The purpose of the carrier, it is thought, was to ensure a reference frequency for the unstable receivers of those days. No information is provided in the drawing as to the relative

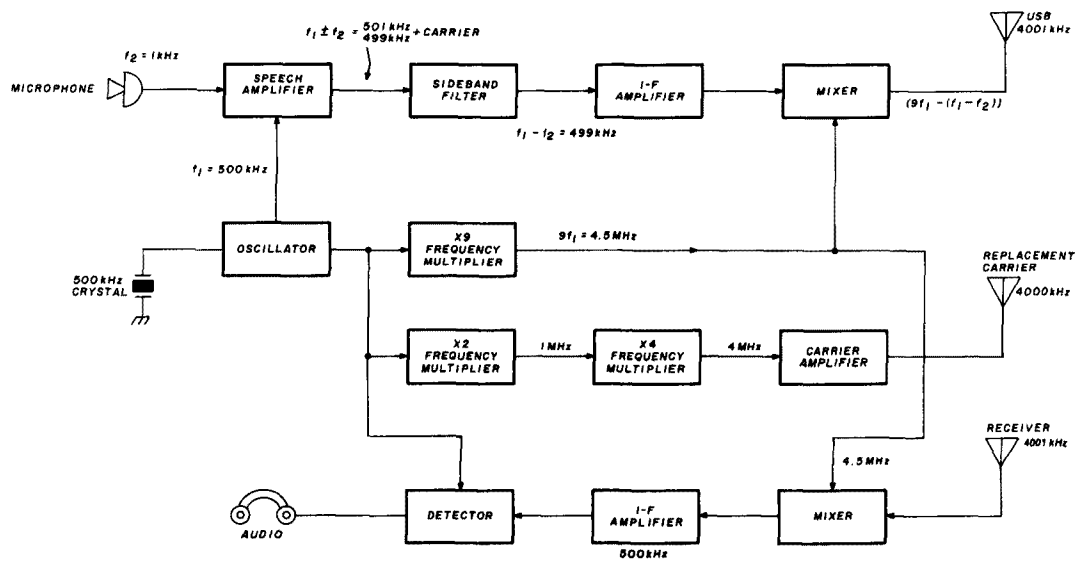


fig. 2. Block diagram of the 1937-model SSB transceiver designed by W1AL. Transmitter portion is at the top, with the receiver portion at the bottom. All injection frequencies were generated by a 500-kHz oscillator. This single-frequency design transmitted USB at 4 MHz. Because of the difficulties involved, SSB lay dormant for nearly 20 years, although the principles were well known and commercial SSB circuits had been in service since the early twenties.

signal amplitudes of the carrier and the sideband signal.

The lower portion of the sketch represents the receiver portion of the transceiver. Referring to the block diagram, the incoming signal at 4.001 kHz is mixed with the 4.5-MHz injection signal and the resulting signal, at 499 kHz, is amplified and passed to a diode detector receiving mixing voltage from the 500-kHz crystal oscillator. The audio signal developed is passed to a headset and the eager operator.

W1AL clearly understood the principle of frequency synthesis, as all his mixing voltages were derived from a single crystal-controlled oscillator. To make sure everything functioned as it should, a diode monitor was added that sampled the carrier and the sideband signal.

So there it was! A breath-taking new concept that eventually would change Amateur Radio and commercial high-frequency communications techniques. But did this startling technique ever appear in *QST*? A look through the 1938 index and a search of the individual issues of the magazine reveal nothing. What had happened to the great idea?

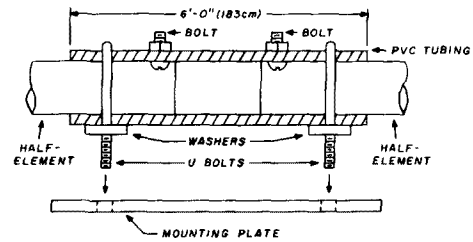
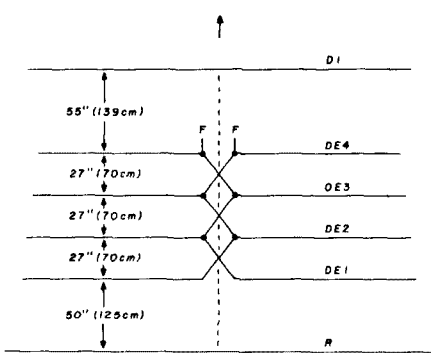


fig. 4. Log-periodic elements are insulated from the boom by a length of PVC plastic tubing. Two top bolts pass through element and tubing to make connections to transposed transmission line made of 1/4-inch-diameter tubing. U bolts passed over PVC tubing to clamp element firmly to mounting plate, which is attached to boom by two additional U bolts.

In a personal discussion with Jim Lamb (now living in California), I learned that the idea had been rejected by the General Manager of the League, at that time Kenneth Warner, because there was no interest in single sideband among Amateurs: the concept was too complex for Amateurs to understand, and the transceiver would be too expensive to build and too complicated to align. Thus the transceiver slumbered for two decades until postwar interest in this novel means of communicating brought SSB into the Amateur bands to stay.

QST comfortably avoided SSB until the fall of 1947, when Mike Villard, W6QYT, and Art Nichols, WØTQK, appeared on SSB working Amateurs on 80 and 20 meters. (Before this date, one or two experimental Amateur SSB stations had been on the air, but their transmissions seemed not to be of general interest.) Now, the time was ripe. The January, 1948, issue of *QST* editorialized on the virtues of "single-sideband, suppressed carrier" transmission, and actual operational SSB equipment was featured. But by now Jim Lamb had left the League; it would be up to others to carry forward his far-sighted communications concepts.



ELEMENT	LENGTHS	
	ENGLISH	METRIC (cm)
D1	14' - 11"	(453)
DE4	14' - 5"	(440)
DE3	15' - 2"	(462)
DE2	15' - 8"	(482)
DE1	16' - 6"	(503)
R	18' - 1"	(553)

fig. 3. Top view of LPY beam for 10 meters. Design covers the complete range of 28.0 to 29.7 MHz with low value of SWR. Ideal for solid-state transmitters. Beam is fed at F-F with 4-to-1 balun and 50-ohm coaxial line. Overall boom length is 15 feet 8 inches (4.7 meters). Design adapted from JH1ZGA, as shown in *CQ-ham radio* magazine (Japan).

a six-element wide-band beam for 10

As every 10-meter enthusiast knows, it is a difficult task to cover the whole 10-meter band with most of the common Yagi or quad antenna designs. If the beam is tuned at, say, 28.6 MHz for operation at the lower end of the band, gain and front-to-back ratio start going to pot near 29 MHz — and at the top end of the band, 29.7 MHz, the beam is relatively worthless. The same is true for beams peaked at the high end of the band: operation is severely hampered at the low-frequency end.

JH1ZGA, a Japanese Amateur

writing in *CQ-ham radio* magazine (Japan), has solved this problem with an adaptation of the log-periodic principle to the Yagi antenna. He describes a homemade LPY (log-periodic-Yagi) beam consisting of four LPY elements plus a reflector and a director (**fig. 3**). The beam is easy to build, requires no adjustment, provides nearly uniform gain across the band, and exhibits an SWR figure ranging from about 1.5-to-1 at 28.0 and 29.7 MHz to 1.1-to-1 at the design frequency of 28.6 MHz. Now, that's hard to beat!

The beam is built on a 2-inch (5-cm) diameter boom, 15 feet 8 inches (4.8 meters) long. The elements are tapered, made of telescoping sections of aluminum tubing, the largest sections being 1 inch (2.5 cm) in diameter and the smallest being about 7/8 inch (2 cm) in diameter. Element lengths and spacings are given in the drawing.

The transposed transmission line running between the elements is made of 1/4-inch-diameter tubing, with the ends flattened to fit over the inner mounting bolts of the elements.

The reflector and director elements are clamped directly to the metal boom, whereas the four driven elements of the log-periodic cell must be insulated from the boom. There are a number of ways of doing this. The original JH1ZGA design calls for the elements to be slipped within a short length of plastic (PVC) conduit pipe, as shown in **fig. 4**. The conduit is then affixed to the boom by means of a U-bolt and mounting plate.

Impedance at the feedpoint (F-F) is about 200 ohms, so a 50-ohm transmission line and a 4-to-1 balun transformer are used to provide a good match.

Since the log periodic cell of four elements provides gain, as do the parasitic elements, the overall gain figure of the beam is approximately equivalent to that of a six-element Yagi. Best of all, the gain and front-to-back ratio are realized across the whole 10-meter band.

a word to the wise

The winter season is coming, with rain, snow, wind, and ice. Before the onslaught of bad weather it is a good idea to examine your antenna installation to make sure it will stay up when bad weather hits. The *before* and *after* photos of **figs. 5** and **6** show what happened to one East Coast Amateur whose enthusiasm for a big signal was greater than his ability to install a proper support structure. The 90-foot telescoping tower had three stacked monoband beams mounted on a heavy steel mast protruding from the top of the tower. A huge rotator was mounted at the top of the tower, too. The tower was firmly anchored at the base and house roof, and was self-supporting. But the designers of the tower clearly indicated in the data sheet what the maximum wind loading for the tower was; it was ignored. The result was that the tower twisted in heavy gusts of wind and the whole schmeer came crashing down one stormy night. Luckily, the mess landed in the yard and no one was injured.

The unlucky Amateur is now back on the air with his big beams, but the whole antenna installation has been redesigned by a certified mechanical engineer to make sure that it will withstand winter weather.

You may not have a problem as serious as this, but the moral is clear — make sure your antenna installation is robust enough to withstand the coming winter storms!

more on interference

My remarks last month on RFI (radio frequency interference) merely touched the tip of the iceberg. RFI is rapidly getting out of hand. RFI is a double problem that comprises both interference *to* communicators (Amateurs, CBers, and commercial communication circuits) and interference to others *by* communicators.

RFI travels from place to place by radiation, induction, or conduction. Radiation is electromagnetic propa-

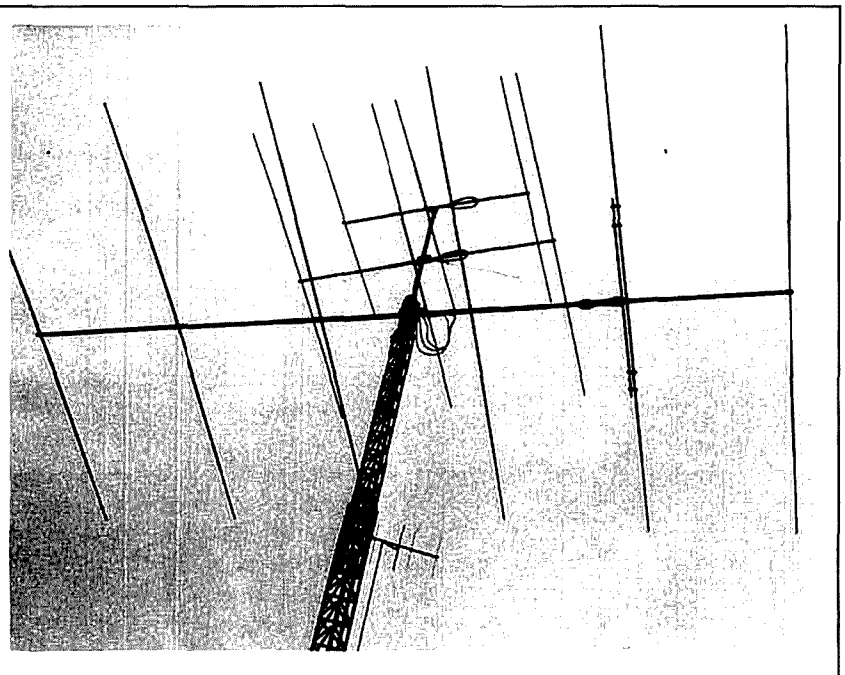


fig. 5. July. 1980. The high-power antenna farm of a prominent East Coast DX-er before the winter storms hit. The self-supporting crankup tower held stacked 20-, 15-, and 10-meter arrays, a heavy-duty rotator, and a side mounted 2-meter beam. All worked well until.....

gation through space. Conduction is transmission through an electrical circuit. Induction is transmission by means of a magnetic field. Transmission of RFI by an electrostatic field is also possible.

In practical terms, this means that radio noise can be radiated from the source to a nearby receiver, or can be coupled to the receiver through a common power source, or radiated from the power line to the receiver, or induced by proximity of source and receiver power lines.

RFI can be cured or attenuated in the majority of cases by a systematic investigation of the noise source and the transmission path. An important tool in the investigation of power-line RFI is a portable, multiband, battery-operated receiver with a built-in loop-stick antenna. The directional properties on the broadcast band of such a receiver will indicate a direction in which the interference source probably lies. Driving about an area "infested" with power-line noise usually provides a general indication of the noise source.

An important point to remember is that the area blanketed by interference is inversely proportional to the frequency of reception. That is, the closer the investigator gets to the noise source, the higher in frequency it can be heard. Thus, while listening a great distance from the noise source, it may be heard in the broadcast band but cannot be heard at, say 5 MHz. Drawing closer to the source, it can then be heard at 5 MHz but not at 30 MHz. Drawing still closer, the noise may be loud at 30 MHz, but barely audible at 100 MHz. At this point, the search can be shifted into the fm broadcast band (88-108 MHz) or into the Amateur 2-meter band.

Interference caused by radio transmitters of all types can be tracked in much the same manner with a directional antenna, although tracking is done on the frequency of transmission (or on a harmonic frequency). Perseverance, experience, and several receivers in an automobile can work wonders in the interesting and practical art of RFI tracking.

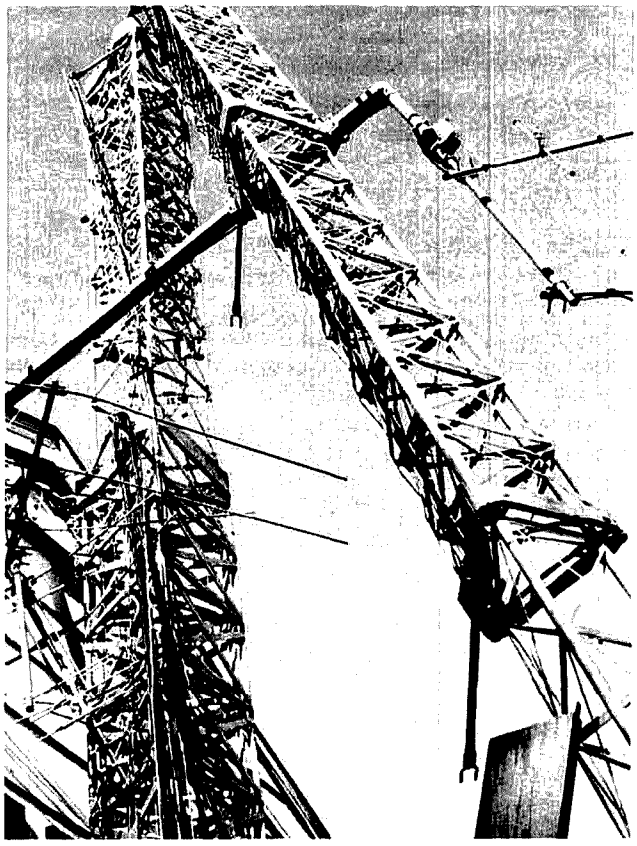


fig. 6. The winter storms hit, and the tower fractured at mid-joint. Luckily, no one was injured when all of this metel tumbled down from the sky. Is your antenna designed to stay up?

the spark discharge

The spark discharge is a common source of radio noise and TV interference, and it can be generated by a number of sources. The discharge sounds like a buzzing, rasping, popping noise, and appears as a band of horizontal dot-dash lines moving slowly up the screen of a television receiver. The width and intensity of the lines are dependent upon the strength and severity of the interference.

One prolific source of radio noise caused by spark discharge is the neon sign. High voltage is required to operate a neon sign, and radio noise can be caused when the neon pressure in the sign drops, causing flickering. The on-off ionization of the gas causes the radiation of a rough, spark-like radio noise that can travel for a great distance.

WA6FQG, Bill Nelson, an experienced RFI investigator, discovered bad interference on his own ham set one day. With the aid of his rotary beam he found the general direction of the noise and tracked it to a neon sign more than three miles distant. It was an animated sign over a nightclub. First, the letters *TOP* would flash, followed by the letters *LESS*, and then the complete word *TOP-LESS* would flash.

Bill told the owner of the sign that it was causing severe interference to radios in the vicinity, but the owner couldn't care less. He told Bill that he

was probably the ham they were always hearing on the stereo whenever the topless dancers were at their best.

The sign is still flashing, but, luckily, Bill was planning to move away soon. Information Bill provided about RFI filters and sign maintenance fell on deaf ears. The dancers are still twirling their tassels and the neon sign flickers to this day. You win some, you lose some.

Bill Nelson is one of the nation's top-notch RFI investigators, who's done this type of work for over two decades for a large California public utility. He's summed up his vast knowledge of RFI in a new handbook, *Radio Frequency Interference* (Radio Publications, Wilton, Connecticut 06897). It's available from Ham Radio's Bookstore, Greenville, New Hampshire 03048, for $8.95 plus $1.00 for shipping and handling. I've had a pre-publication look at Bill's book and it is good.

an interesting observation on TVI

Interference caused by harmonics of the television receiver's sweep oscillator can be a nuisance on the Amateur high-frequency bands. They were not much of a problem to me on 20 meters, but recently when I tried 80 meters, the devilish buzzing signals nearly obliterated the band. While gazing at the TV receiver and wondering what to do, I noticed that the receiver has a three-wire, 120-volt power cable and that it was plugged into a two-pronged wall outlet. An adapter plug was used that matched the three-prong TV plug to the wall plate. The ground wire of the three-wire cable was attached to a pig-tail on the adapter. I noticed the pig-tail had not been grounded to the conduit bolt on the wall plate, but left hanging in midair.

Grabbing a screwdriver, I immediately attached the pig-tail to the wall plate bolt (**fig. 7**). Checking my receiver on 80 meters, I noted happily that the S-meter reading on the TV

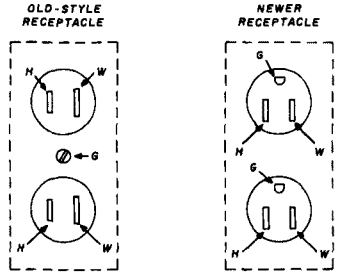
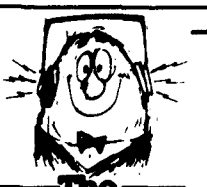


fig. 7. Many homes built during the fifties and sixties are wired with wall plugs shown at left. The neutral wire (white, W) with a nickel screw is unfused and at, or near, ground potential. The other wire (black, red or blue with a brass screw) is hot, H. In most instances a third ground wire is run between all metal receptable boxes (G) and is grounded at the meter box. At the right is the newer receptacle in use since mid-sixties. Equipment ground (G) is separately grounded at the meter box and is coded green. House wiring varies from town-to-town, so check yours and don't assume this wiring information is universal! If in doubt make the equipment ground connection through an 0.01 μF, 1.4 kV ceramic disc capacitor.

oscillator harmonics had dropped nearly a quarter-scale! In 20 seconds of work I had reduced the racket from unbearable to merely annoying! Moral: Check your TV receiver. If the ground prong of the power plug is not grounded to the equipment ground wire of your wiring system, it would be a good idea to make this connection.

A few days later I tossed out the two-prong wall plate and substituted a new three-prong plate which automatically grounded the equipment ground wire of the TV power cord. Since modern appliances are all equipped with a three-wire power cable, examine your wall receptacles. If they have two conductors plus an equipment grounding wire, replace the old two-connector receptacles with modern three-connector designs. Wiring instructions are included with the new receptacles.

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Feedback amplifiers, i-f filters, i-f detectors, frequency synthesizers: part 2

Part 1 of this article, which appeared in the November, 1981, issue discussed new approaches to receiver design, microprocessor applications in receivers, input filters, and input mixers. In this, the second and final part, I address feedback amplifiers, i-f filters, i-f detectors, and frequency synthesizers.

feedback amplifiers

The grounded field-effect transistor circuit using the CP643 has an intercept point of 35-40 dBm relative to the output, which means that the gain (about 10 dB) must be deducted from the input. The noise figure depends on the source resistor. If the driving source is in the vicinity of 50 ohms, the noise figure will be about 3 dB. To get a lower noise figure a higher drive impedance is required.

Texas Instruments in Germany made a high-power field-effect transistor called the P8000, then replaced it with the P8002. This transistor has about 2-dB noise figure when driven at 50 ohms. In addition, it uses a special metal housing and can dissipate more heat. This transistor appears to have been discontinued, but some are available from me (send an SASE).

A further reduction in noise with the same intercept point can be obtained by using feedback. The BFT66, made by Siemans (about $3 each) exhibits a noise figure of about 1 dB and an intercept point of almost 40 dBm when used in the feedback circuit shown in **fig. 6.**

Noiseless feedback circuit. The circuit can be analyzed under the simplifying assumption that the common-base transistor has an input impedance of 5 ohms, an infinite output impedance, and unity current gain, while the transformer is considered to be ideal. With these assumptions, it can easily be shown that a two-way impedance match to Z_o will be obtained if the transformer ratio is chosen such that $n = m^2 - m - 1$. With this choice the power gain will equal m^2, the load impedance presented to the collector will be $Z_o\ (n + m)$, and the source impedance presented to the emitter will be $2 \times Z_o$.

Usable turns ratios are obtained for $m = 2, 3$, and 4, yielding gains of 6, 9.5, and 12 dB and load impedances of $3, 8$, and $15 \times Z_0$ respectively.

It is seen that, similar to a conventional common-base amplifier, the gain of the stage is determined by the ratio of load impedance, Z_l, to the input impedance, Z_{in}. In this case, the gain is given by $Z_l/Z_{in} + 1$; whereas it is just Z_l/Z_{in} in the conventional configuration. The significant difference is that the transformer-coupled device provides a two-way impedance match, which is obtained by coupling the load impedance to the input and the source impedance to the output through the action of the transformer.

The dynamic range considerations for this device are similar to those of the directional-coupler circuit but with some important differences. First, the operation of the circuit depends on the completely mismatched conditions presented by the transistor to the circuit; that is, the emitter presents a short circuit and the collector an open circuit. Hence there is no requirement to introduce resistive elements for impedance matching as there was in the directional-coupler circuit. Therefore, a noise figure advantage is obtained with this circuit. Secondly, the source impedance of $2 \times Z_o$ presented to the emitter tends to give optimum noise figures. Finally, despite the small currents involved, relatively large output powers can be provided because of the high load impedance, which goes along with the higher gain versions.

The main disadvantage of the circuit is that the

By Dr. Ulrich L. Rohde, DJ2LR, 52 Hillcrest Drive, Upper Saddle River, New Jersey 07458

high load impedance tends to limit the bandwidth. Nevertheless, sufficient bandwidth can be achieved to provide broadband i-f gain with noise figures competitive with those which could previously be obtained only in very narrowband units.

As it is desirable to keep the dc operating level over a wide temperature range, an additional bias circuit was developed that maintains almost temperature-independent biasing.

Two-stage low-noise amplifier. Fig. 7 shows a two-stage amplifier that will operate up to 1,000 MHz using this low-noise technique. The output lowpass filter prevents harmonics from occurring at the output. If this circuit is used as the second i-f following the crystal filter of a receiver and drives the second mixer to obtain a lower i-f of, say, 9 MHz, we don't want any harmonics at the output that may cause intermodulation distortion products.

Two BFT66 stages are shown cascaded; the first with temperature-compensating bias. Depending on the turns ratio of transformers T1 and T2, different gains can be obtained. It's desirable to place the tap at the output transformer output so that the transformed input impedance is equal to 50 ohms.

Several other combinations of this amplifier are possible, and its significant advantage over previously published circuits is that it uses transformer, or "noiseless," feedback rather than resistive feedback, therefore the noise figure is substantially lower.

high-dynamic-range amplifiers

Conventional amplifiers built from single-stage circuits suffer from in-band intermodulation distortion, and the previously described noiseless feedback circuit can only be set at gain values depending upon even turn ratios, as discussed.

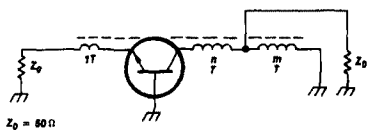


fig. 6. The noiseless feedback circuit using a BFT66 with a noise figure of about 1 dB. An intercept point of almost 40 dBm is possible.

Let's look at fig. 8, in which we see the second mixer of a receiver where the first i-f is converted to a lower i-f such as 9 MHz. The output of the second mixer operates into a diplexer and, therefore, splits up the energy. The drive into the amplifier is therefore reduced by 3 dB, as only one sideband is available.

We find the familiar BFT66 circuit and a PNP/NPN output stage. Since this stage really is an emitter follower, its inherent feedback keeps the distortion low and the low drive impedance allows matching into various impedances.

This circuit is driven from the high-input-impedance point (collector) of the BFT66. To prevent any changes in output impedance, the output transformer of the BFT66 is terminated with 56 ohms. As a result, the PNP/NPN circuit has power gain, very little

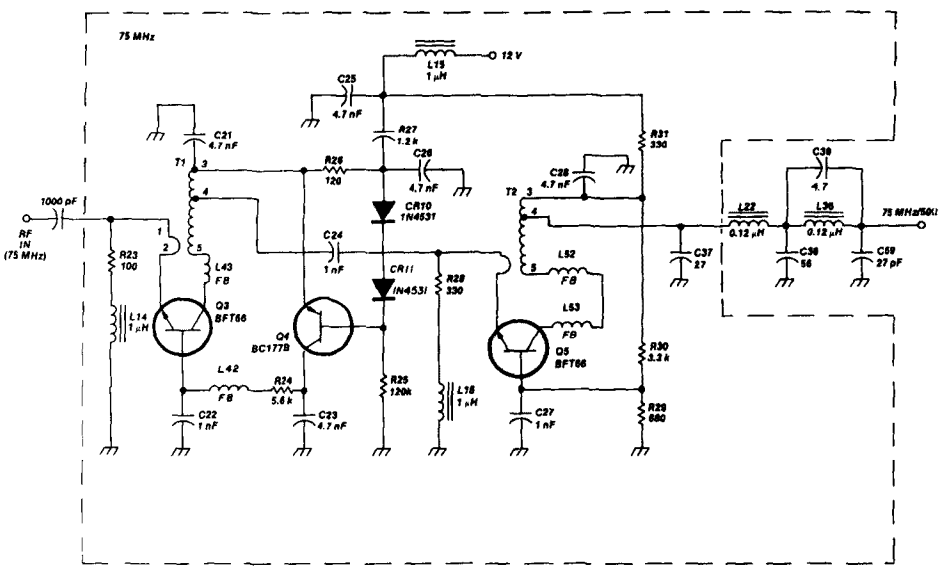


fig. 7. Two-stage amplifier with two BFT66 transistors that can be used as a mixer termination.

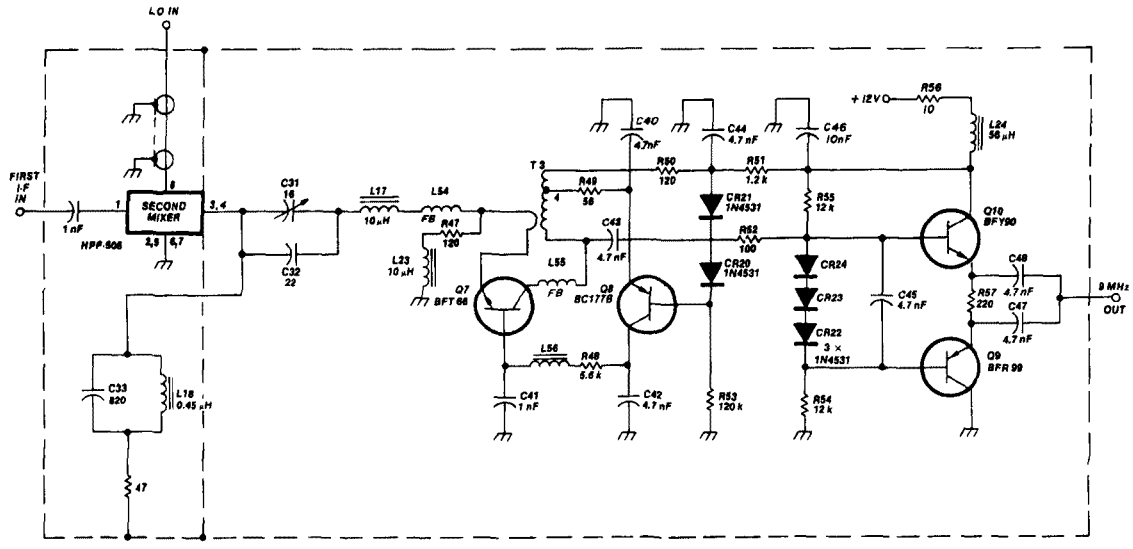


fig. 8. Second mixer of a receiver chain, including the diplexer, low-noise amplifiers, and power-output stage.

feedback, and extremely low distortion. The noise figure is now determined by the BFT66 stage, and the second stage contributes very little. The other advantage of this circuit is that there are no tuned circuits; therefore, it can be used from a few hundred kHz to almost 100 MHz. This makes this circuit design very useful.

i-f filters

I mentioned earlier that there is a distinct difference between static and dynamic selectively. Static selectivity of a filter is defined as the selectivity one measures if a point-to-point measurement is taken and the curve is then plotted. If this is done more rapidly and we start to sweep the filter, then depending upon the sweep time the picture is going to change.

First, the filter shows a delay, which means it takes a certain number of milliseconds or microseconds before the signal arrives at the output. From the use of noise blankers, we note that a crystal in the receiving passband acts as a pulse stretcher, which means that the pulse of extreme amplitude and longer duration is changed into one of considerably lower amplitude and substantially lower duration. This effect is equal to the ringing noticed in reception of Morse code.

From the literature we know that several crystal filter types are available. Originally, one started out with mechanical filters, and the earlier mechanical filters also exhibited excessive ringing. The dynamic response of a filter is determined by its design. A filter with a rectangular-shaped response has the highest selectivity and the highest ringing.

Let's consider a 200-Hz CW filter with a shape factor of 3 and a substantial phase jump on the corners, which therefore results in excessive nonlinear distortion and ringing. In my recent paper,[3] I presented several crystal filter computer programs and showed how to design crystal filters that avoid this ringing.

First of all, from filter theory, it is known that a single-tuned circuit has the least amount of ringing but insufficient selectivity. To duplicate a 6-8 pole crystal filter, 6-8 discrete tuned circuits isolated by an amplifier are required. This is called synchronous tuning, and modern spectrum analyzers are still using this approach. If the bandwidth must be changed,

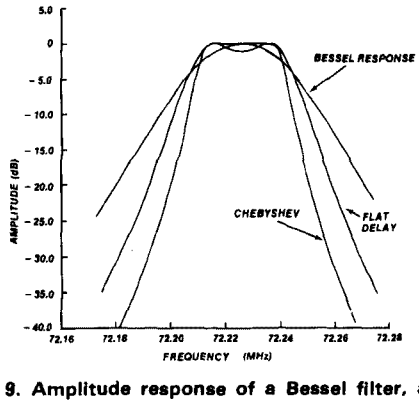


fig. 9. Amplitude response of a Bessel filter, a filter with flat group delay, and a Chebychev filter.

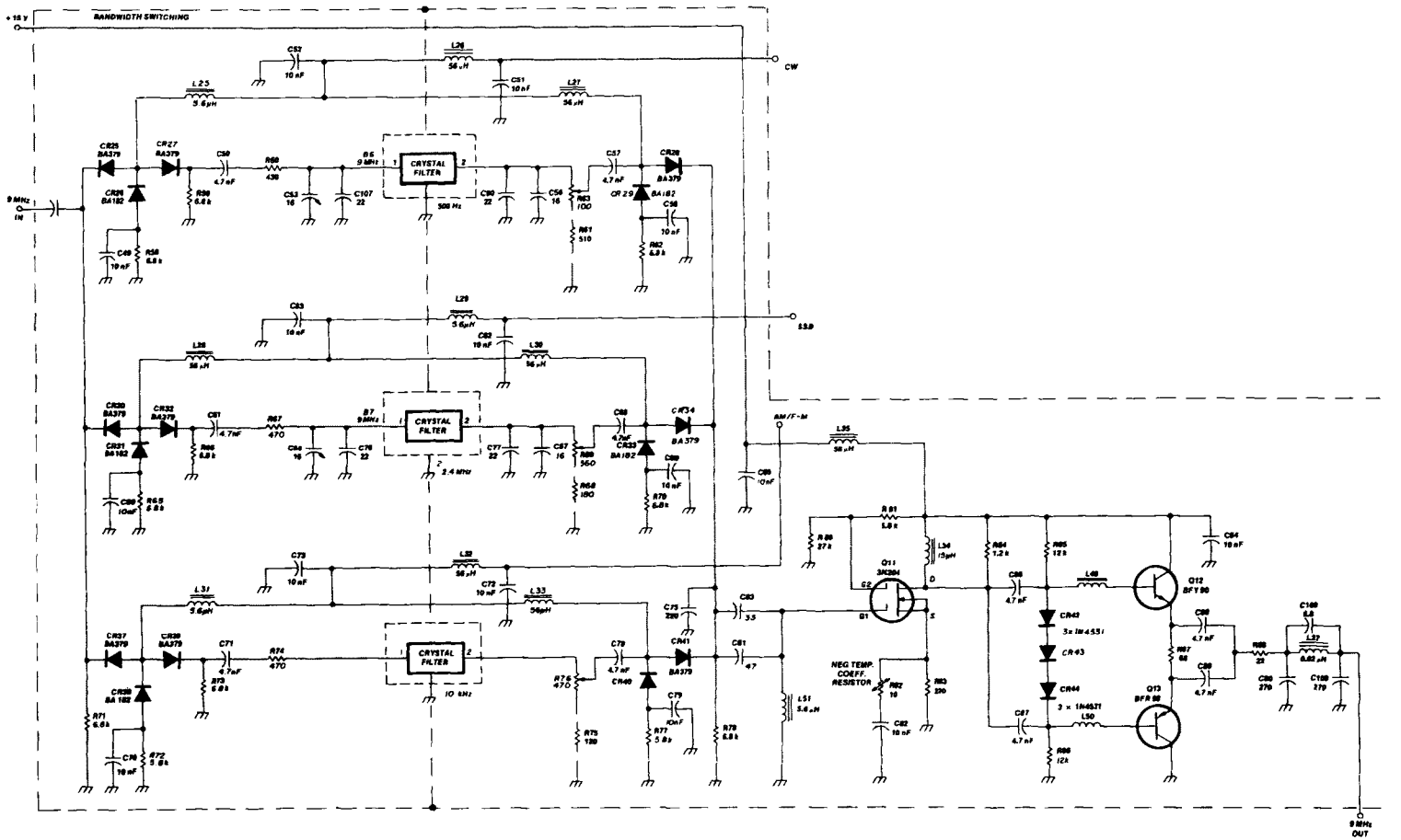


fig. 10. I-f section containing three i-f filters, switching arrangement, gain adjustment, and temperature-compensated high-level output stage.

each filter circuit must be tuned with a tracking circuit, which makes these analyzers expensive but gives perfect response. Mathematically, the equivalent of such a filter is "Gaussian shaped." It has the poorest selectivity but the best pulse response.

It should be noted that, for Amateur purposes, both CW and SSB are basically pulse-type modulation. In both cases, there is no carrier and no constant level. However, in the case of single sideband signals, several frequencies of different amplitude are available simultaneously. The human voice has harmonics, and if the circuit introduces distortion, we have a wider or splattered signal. Therefore, the single-sideband filter energy both inside the bandwidth and outside the bandwidth bounces against the skirts.

Let's take a look at **fig. 9**, which shows the three most important types of filter curves: Bessel response, flat delay, and Chebyshev. The Bessel response is an approximation of the Gaussian filter with improved skirt selectivity. The flat delay filter exhibits a constant group delay, or a group delay with an extremely small ripple. As a result, the pulse response and skirt selectivity are excellent. The disadvantage of this filter is its somewhat higher insertion loss. Finally, as a comparison, we see the Chevyshev filter with the familiar flat top in the passband, while the flat-delay filter shows a slight dip.

These filters are based on certain mathematical equations, as is the elliptical filter, which is not elliptical in the sense that it looks elliptical, but rather certain equations, called elliptical integrals, are used to calculate its characteristics. Modern computers and desktop calculators use these filters. I am currently evaluating some new types of filters that are computer optimized and easy to build.

The ultimate rejection of these filters is an important parameter, and also the termination on both sides affect performance. It is therefore very important how these filters are inserted into the circuit. Fig. **10** shows a recommended method using switching diodes and having a provision to adjust for the different gains at the different bandwidths. The German company, KVG, makes excellent filters. Their CW filter, XF9NB (available from Spectrum International), has a superior ringing performance.

For single sideband we find only one filter. If we change both the BFO as well as the second LO frequency in the receiver by 3 kHz, we can eliminate the second filter and still maintain a correct dial reading. In the section on frequency synthesizers, I show a simple circuit that can be used for the second LO and the BFO to shift the crystal frequency against an internal standard — a less expensive solution than using two filters.

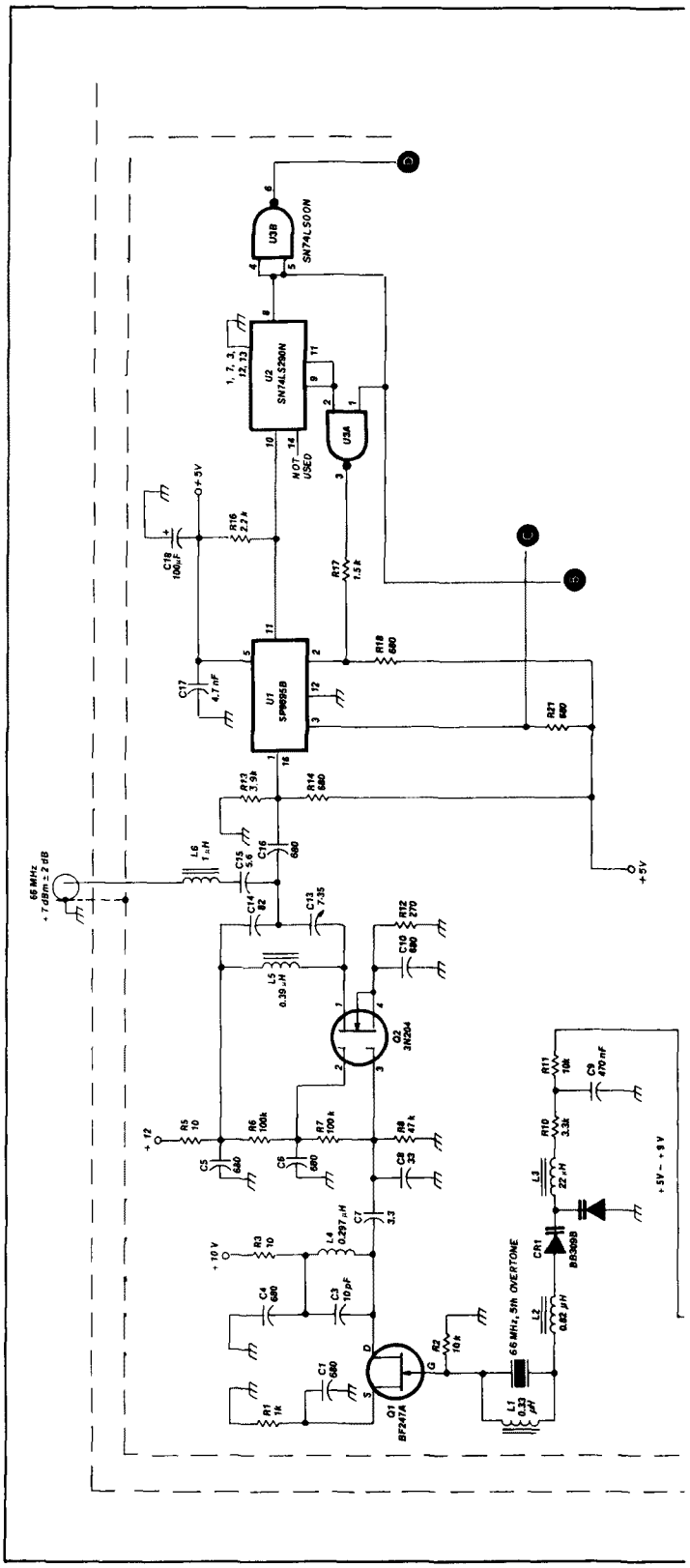
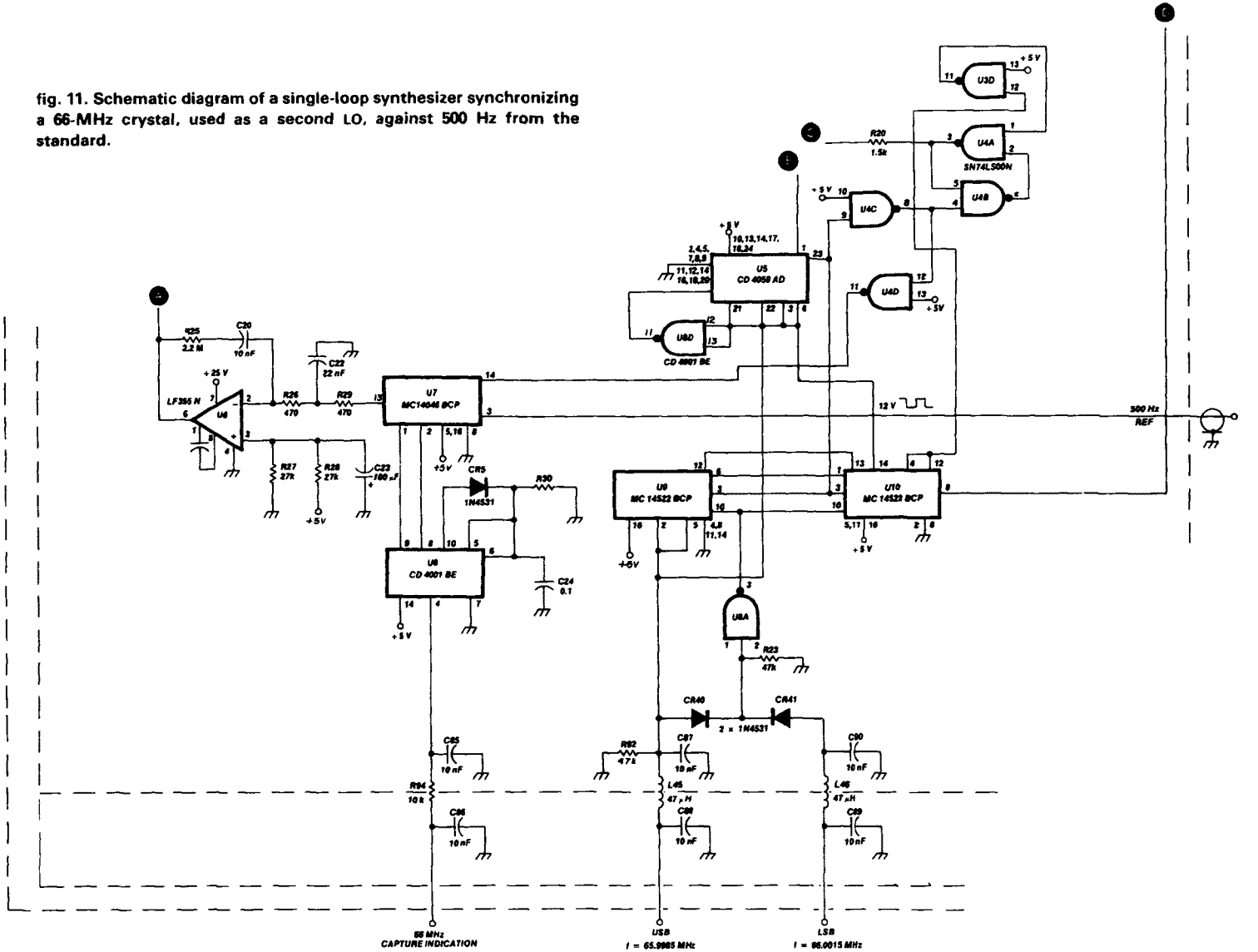


fig. 11. Schematic diagram of a single-loop synthesizer synchronizing a 66-MHz crystal, used as a second LO, against 500 Hz from the standard.



i-f detectors

Multimode receivers require a-m, fm, and SSB detectors. Since we want the audio at the same level, *gain adjustments must be* provided. Probably the best and least expensive solution for this problem is to use the SL624 Plessey IC. This chip contains the detection circuits for all three modes of operation.

Another attractive solution is to use the SL624 for fm only and the SL623 only for SSB and a-m, which allows somewhat greater flexibility in the design parameters. A third solution is to use the SL640/41 as the product detector if only SSB is required. This product detector requires the least amount of components but is not used very frequently. While it is more forgiving as far as high i-f levels are concerned, it is also less well known. A summary of i-f circuits is found in reference 4.

frequency synthesizers

Earlier I mentioned that we need a synthesizer for the BFO and for the LO. Having the BFO and LO synthesized allows i-f shifts and/or allows the use of the 2.4-kHz filter for both upper and lower sideband. **Fig. 11** is the schematic diagram of a synthesizer with a voltage-controlled crystal oscillator that is used as the second LO, and the 66-MHz crystal can be pulled ± 1.5 kHz. The same technique can be used to build a BFO synthesizer by expanding the number of dividers and using a "soft" 9-MHz crystal. It is possible to pull a 10-MHz crystal about 1 or 2 kHz, and if the reference fequency is set at 100 Hz, this should be sufficient resolution to build an i-f shift system. New approaches are being developed to design simpler synthesizers. The most important is the fractional-N synthesizer, which is discussed below.

Conventional single-loop synthesizers use frequency dividers in which the division ratio, N, is an integer between 1 and several hundred thousand, and the step size is equal to the reference frequency. Because of loop-filter requirements, the decrease of reference frequency automatically means an increase of settling time.

It would be unrealistic to assume that a synthesizer with a reference lower than 100 Hz can be built, because the large division ratio in the loop would reduce loop gain so much that tracking would be very poor and the settling time would be several seconds.

If it were possible to build a frequency synthesizer with a 100-Hz reference and fine resolution, this would be ideal because the VCO noise from 2 or 3 kHz off the carrier could determine the noise sideband; while the phase noise of frequencies from basically no offset from the carrier to 3 kHz off the carrier would be determined by the loop gain, division ratio, and reference. Because of the higher reference frequency, the division ratio would be kept smaller. Traditionally, this conflicting requirement has resulted in multiloop synthesizers.

An alternative would be for N to take on fractional values. The output frequency could then be changed in fractional increments of the reference frequency. Although a digital divider cannot provide a fractional division ratio, ways can be found to accomplish the same task. The most frequently used method is to divide the output frequency by $N + 1$ every M cycles and to divide by N the rest of the time. The effective division ratio is then $N + 1/M$, and the average output frequency is given by:

$$f_o = \left(N + \frac{1}{M}\right) f_r \qquad (1)$$

This expression shows that f_o can be varied in fractional increments of the reference frequency by varying M. The technique is equivalent to constructing a fractional divider, but the fractional part of the division is actually implemented using a phase accumulator. The phase accumulator approach is illustrated by the following example.

Consider the problem of generating 455 kHz using a fractional-N loop with a 100-kHz reference frequency. The integral part of the division is $N = 4$, and the fractional part is $1/M = 0.55$ or $M = 1.8$ (M is not an integer). The VCO output is to be divided by five ($N + 1$) every 1.8 cycles, or 55 times every 100 cycles. This can be easily implemented by adding the number 0.55 to the contents of an accumulator every cycle. Each time the accumulator overflows (contents exceed 1), the divider divides by five rather than four. Only the fractional value of the addition is retained in the phase accumulator.

Arbitrarily fine frequency resolution can be obtained by increasing the size of the phase accumulator. For example, with a 100-kHz reference frequency, a resolution of $10^5/10^5 = 1$ Hz can be obtained using a 5-BCD accumulator.

This technique is being used in the Racal RA6790 and in some Hewlett-Packard signal generators. A more detailed description of this can be found in reference 5. Research engineers at Phillips have recently used a similar technique and have built a two-chip frequency synthesizer, HEF 4750 and HEF 4751, which is being distributed by Signetics. With these two chips and very little external circuitry, it is possible to build a synthesizer system to more than 1000 MHz with 100-Hz step size. As the single-loop synthesizer is the cleanest of all the synthesizers, and as the noise sideband depends highly on the VCO, this new technique will mean a reduction in price and an increase in performance of simple synthesizers.

Signetics has several good application reports

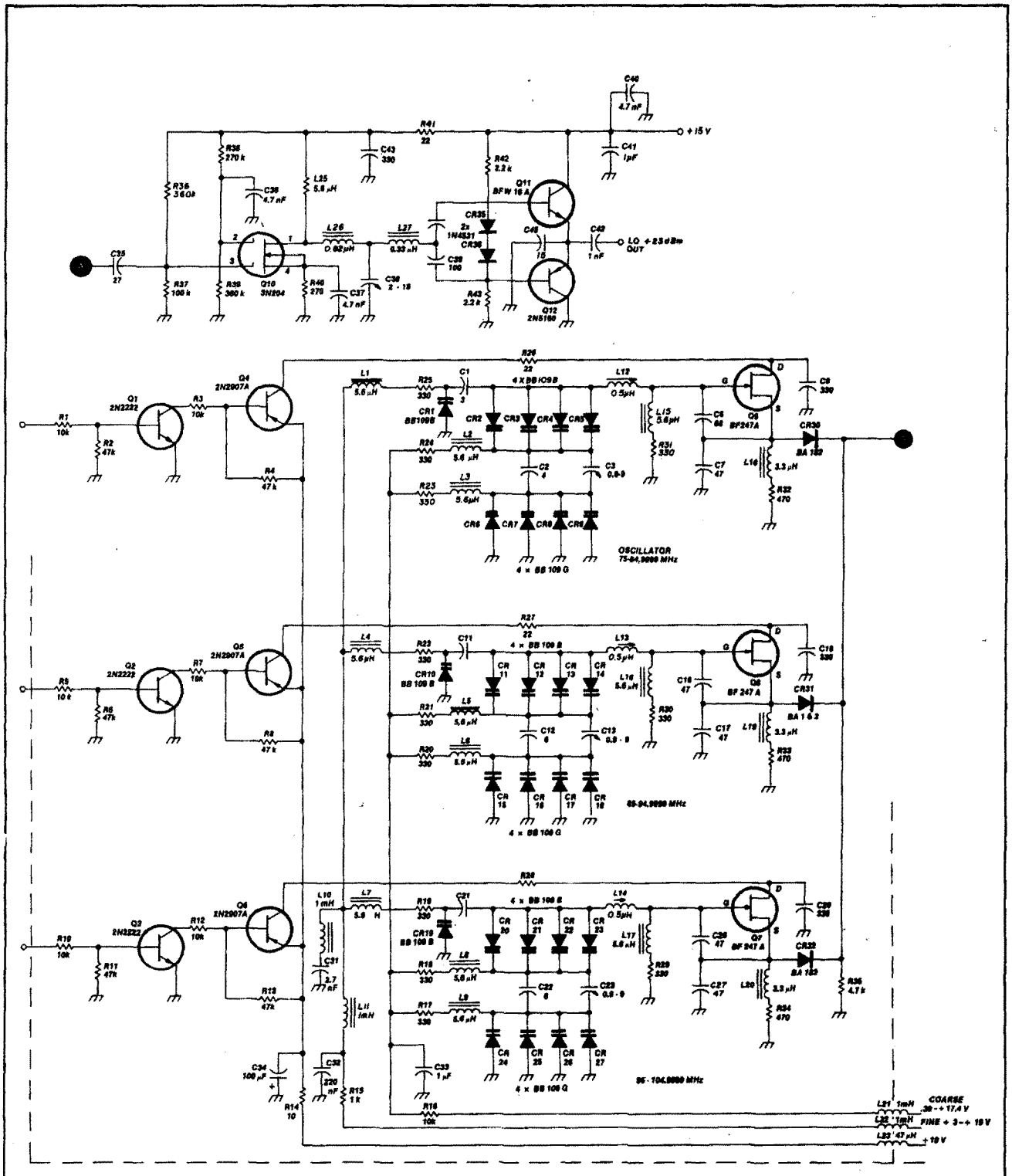


fig. 12. Schematic diagram of three low-noise VCOs with coarse and fine tuning input, select circuits, and 23-dBm post amplifier, recommended for shortwave receivers.



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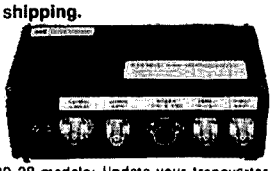
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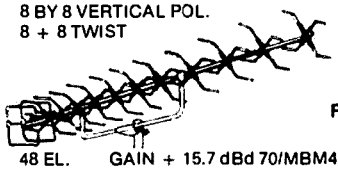


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available for this synthesizer device. Its prime advantage is that a single-loop synthesizer can be built that uses a reference such as 1 kHz, and a resolution or step size of 100 Hz can be obtained, which is ten times the resolution. This is done in a technique similar to that of the fractional *N*, and the lockup time is determined by the 1-kHz reference loop filter rather than the 100-Hz filter system.

As the VCOs are so important, fig. 12 shows a combination of three VCOs, each covering 10 MHz. They can be used for a 10-kHz to 30-MHz receiver with a 75-MHz i-f. The coarse tuning can be accomplished using a digital/analog converter, and the fine tuning can be done by the synthesizer. It is recommended that a two-bit D/A converter be used, which means that the frequency is coarse and preset with 100 kHz.

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ham radio

the rf-power distributor

Another method for routing rf signals in your station

The problem of rf-power distribution in an Amateur Radio station has been solved using many methods. While visiting other Amateur stations I've observed techniques ranging from manually operated patch cords to the complex, remotely operated, coaxial-relay box.

The rf-power distributor described here will appeal to any Amateur who has several coaxial cables entering his station and the choice of operating more than one transmitter. The unit offers fingertip selection for instant optimizing of any antenna and transceiver combination. It is virtually maintenance free.

typical problem

I have two types of transceivers and three different antennas, each having a feed line. Many Amateurs have worked themselves into a similar situation by adding one antenna at a time followed by a long lapse before the next installation. This action results in a big outlay for coaxial cable, which has been carefully routed down towers, around eaves, and through wall-connecting boxes.

I do recognize that this problem is easily resolved by installing an antenna relay control box, thus eliminating all but one feedline. But with all my feedlines semi-permanently in place (and their expense being history), I chose to place the rf-power distributor in the station on the operating table. Indoor placement of this control also eliminates the possibility of relay malfunctions because of moisture and other problems.

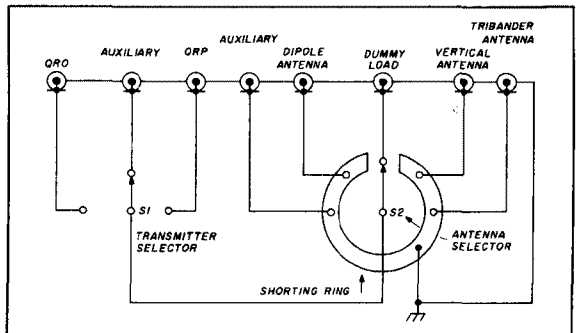


fig. 1. Rf-power distributor circuit diagram.

obtaining parts

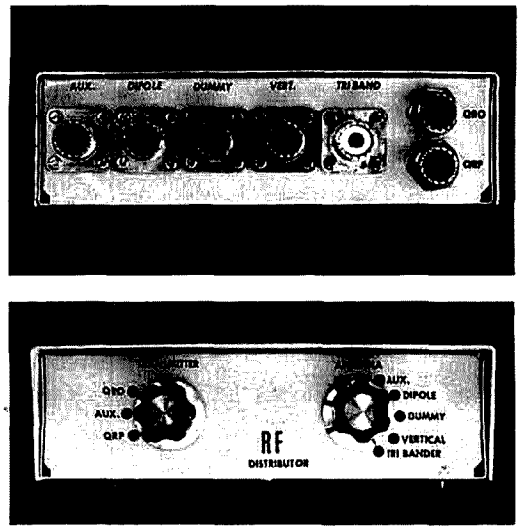
With a well-supplied junk box or a few visits to local hamfests, this project can be produced with a minimum of cost in just a few evenings. The main parts are a handful of SO-239 connectors and two good-quality ceramic rotary switches. The antenna rotary selector switch preferably should be the type that shorts out all but one position. This is a good feature that can be used to ground all but one antenna.

For the cabinet I used a 5×7×2-inch (12×18×5 cm) inverted aluminum chassis. The removable top was cut and formed from a piece of vinyl-covered aluminum. I wired the unit with No. 14 AWG (1.6 mm) bus wire using direct routes. The schematic is shown in **fig. 1**.

construction notes

Two auxiliary positions were included: one for each of the selector switches. I had a limited amount of rear panel space for the connectors, so I wired my auxiliary connector to the antenna selector. If you have more than two rigs and no auxiliary antenna, a simple rewiring job can accommodate your situation. The front panel (photo) is labeled to satisfy either

By F.T. Marcellino, W3BYM, 13806 Parkland Drive, Rockville, Maryland 20853



Front view and rear view of the home made rf-power distributor.

condition. Of course, if you use a larger chassis, the problem will disappear with added connectors.*

The chassis was finished with several coats of DS-GM-283 Green Dupli-Color™ automotive paint. Remember to mask the connector openings to prevent the paint from forming an insulator. The project was completed by installing four rubber feet and a pair of Heathkit knobs. I also included a selector position for my dummy load. For troubleshooting and off-the-air tune-ups this position has been used many times.

Most of my coax cables are the larger type RG-8/U. As a result, they influence the natural resting position of the unit. I solved this problem by sandwiching the unit between my rotator control box and speaker cabinet.

The ceramic rotary switches have a dc-current capability of 3 A. This is adequate for any input-power level up to the legal limit. I use these switches to carry power levels varying from 3 to 1000 W input with no contact degradation or change in the standing-wave ratio. By quickly selecting the proper antenna, I can optimize my station for the band conditions at the moment.

Commercial coaxial-switch boxes have been available for many years. Two of them, at considerable cost, would provide this function. On the other hand, the rf-power distributor described here will do the same job and demonstrates that practical equipment can be inexpensive.

*In this case, you might want to break the line between S1 and S2 in fig. 1 and add two connectors to accommodate accessories such as an SWR bridge or antenna matcher. Editor

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the half-square antenna

Practical information on feeding and operating this popular radiator

The **half-bobtail** or **half-square antenna** has begun to receive a substantial amount of attention in recent Amateur publications. This versatile antenna has yet to make the impression it deserves in actual field use, however. This is due, in my opinion, to a lack of practical information regarding methods of feeding it.

The purpose of this article is twofold. First, it is to discuss examples of feed systems for the half-square antenna that are currently in use at several stations in widely varying environments. Second, it explores the virtues of this antenna as a multiband performer.

The theory of operation of this antenna has been discussed by Ben Vester, K3BC.[1] Interested readers may refer to the bibliography for additional background.

feed system

The basic layout of the antenna is shown in fig. 1. Of primary interest to most Amateurs (beyond performance) is how to connect the coax and get the antenna fired up.

Several feed methods have been examined in terms of available parts, weathering, and ease of adjustment. By far the simplest is the parallel-tuned tank circuit (fig. 2).

Network *L1C1* should resonate at the desired operating frequency. The values of *L1* and *C1* are calculated by:

$$LC = \frac{25{,}350}{f^2} \quad (1)$$

where L = inductance (mH)
C = capacitance (pF)
f = frequency (MHz)

A large value of L for a given frequency is desirable, because it decreases the Q of the LC network, thus increasing the bandwidth of the feedpoint. A value of 13 μH was chosen for L; therefore, for C at 7.15 MHz:

$$C = \frac{25{,}350/7.15^2}{13} = 38.1\ pF \quad (2)$$

In practice, a few additional turns for *L1* are needed. So two or three turns are added (3 μH) to the calculated value for *L1*. In my case, L is made of 15 turns of B&W No. 3033 3-inch (7.6-cm) diameter coil stock, but any 15-μH coil of No. 14 (1.6 mm) or larger wire will handle a kilowatt output.

Coils are easy to procure or wind, but capacitors are expensive, difficult to find, or both. Also, should a variable capacitor be desired for *C1*, weatherproofing becomes a problem. Because of these constraints, I chose a homemade capacitor that could be made from inexpensive RG-8/U coax and easily weather-proofed with silicone sealant.

The capacitor value is calculated using eq. 2, and the appropriate length of RG-8/U cable is determined by the distributed capacitance listed in the literature for the properties of common transmission lines. For RG-8/U the value is approximately 30 pF/foot (98.4

By Robert "Hasan" Schiers, NØAN, Box 1024, ISU Station, Ames, Iowa 50010

pF/meter). Therefore, if 38 pF is required, the desired length is found by dividing the capacitance per unit length for RG-8/U into the desired number of picofarads. That is, *30 pF/12 inches = 2.5 pF/inch (0.98 pF/cm)*, so that *38 pF/2.5 pF/inch = 15.2 inches or 38.6 cm*. A 15.2-inch (38.6 cm) length of RG-8/U will provide a 5-kV capacitor at inconsequential cost. Weather-proofing is important.

It is important to note, however, that until the sealant has cured, it is not an insulator and will short out the capacitor at the treated ends. The capacitor need not slow the project down; rather, it can be assembled and weather-proofed first and set aside to cure while the rest of the project is carried out.

Refer to fig. 3 for capacitor details. The capacitor is formed by the center conductor on one end and the shield on the opposite end. Treat both ends (except for the wire at the connection point) liberally with silicone sealant. This produces a reliable capacitor that will stand high power levels.

The feed system is completed by the input tap setting. A good initial setting is to tap up from the ground side two to three turns for 50 ohms. By using an SWR bridge at the antenna, the tap may be set exactly for a 1:1 SWR at any part of the band you desire. The following is an adjustment procedure that has proven effective (refer to fig. 4):

1. Set input (low-side) tap at 2½ turns up from ground.

2. Set high-side tap at one turn greater than predicted in calculations.

3. Measure SWR across band and note the low point; this is primarily influenced by the high-side tap. If the low point is not in the area of the band you desire, move the tap higher for a decrease in frequency or move the tap lower for an increase in frequency.

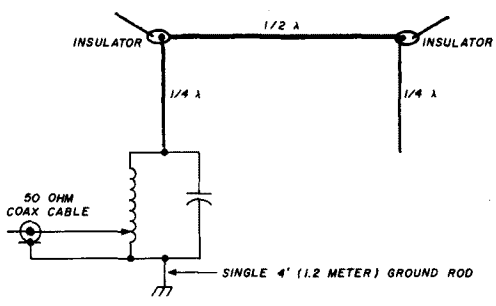


fig. 1. General arrangement of the half-square antenna, which originally appeared in *QST* and later in reference 1. It was described in these publications by Ben Vester, K3BC.

4. Once the low point of SWR has been set at the desired portion of the band (no matter what its value), proceed to adjust the low-side tap ¼ to ½ turn at a time to get a match of 1.2:1 or better at the desired operating frequency.

I've used this approach in three different environments. It has resulted in a match of 1.1:1 in no more than twenty minutes.

multiband operation

As may be seen from the wavelength relationships of fig. 1, this antenna, when constructed for 40 meters, is resonant on several other bands. By merely changing the feed system slightly, the antenna will perform very well on harmonically related bands. For example, the 40-meter array may be operated on 20 meters as a pair of half-wave verticals spaced one wavelength apart. While the phasing is not ideal, the performance of this antenna is very impressive, given the investment of time and money it requires. Table 1 shows the manner in which the antenna can be operated on harmonically related bands and what feed point changes are needed.

performance

At the time of this writing, this antenna has been evaluated in two ways. First, it has been compared

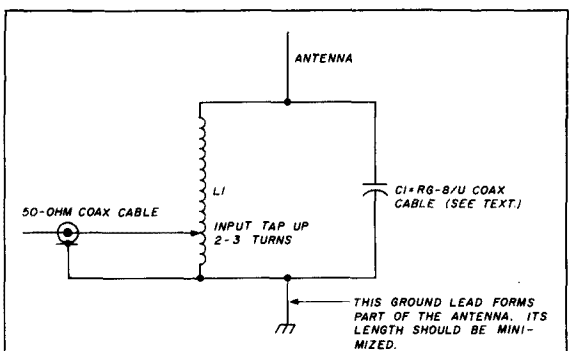


fig. 2. Antenna tuning network consists of a parallel-tuned circuit, which features simplicity and ease of adjustment.

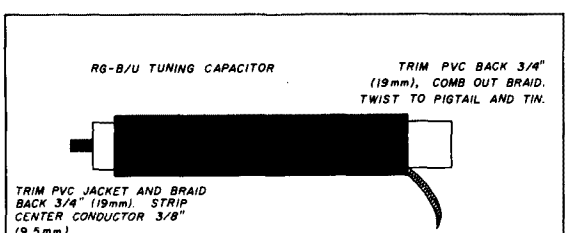


fig. 3. Construction details for the network capacitor.

(by instant switching) with on-site antennas. In comparison with a full-wave loop vertically polarized and mounted 8 feet (2.4 meters) off the ground, the half-square array consistently outperformed the loop by two to three S-units. There were virtually no instances where the loop was superior to the half-square, regardless of time of day, bearing, or distance. The period of these observations was approximately one month of daily use.

This same comparison, that is, loop to half-square, was made in terms of communication effectiveness during the recent ARRL phone SS contest. For a similar 15-minute period (in the same half hour) the half-square array produced over double the number of contacts that were achieved with the loop.

table 1. Characteristics of the half-square antenna as an harmonic radiator. Band design: 40 meters.

Amateur band	antenna operates as	feed
160 meters	¼λ Marconi	bypass tuning network and feed against ground
80 meters	½λ end fed	add ≈ 100 pF across existing coil cap. Input tap need not be readjusted.
40 meters	half-square array	as designed
20 meters	pair ½λ verticals spaced 1λ	tap coil for fewer turns (total). Retap input. Change tuning cap.
10 meters	pair 1λ verticals spaced 2λ	tap coil for fewer turns (total). Retap input. Change tuning cap.

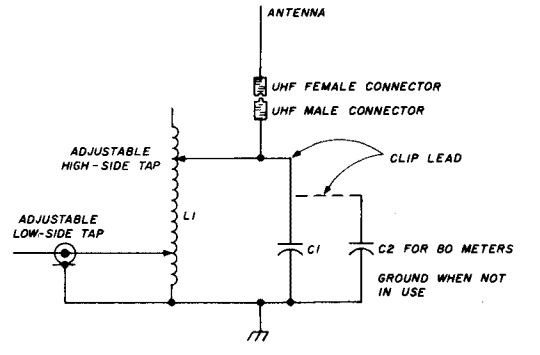


fig. 4. Tuning network is completely adjustable. The inductance is made of 15 turns of B&W No. 3033 coil stock (15 μH); capacitor is made of RG-8/U coax cable as described in the text. In this arrangement C1 is 38.1 pF. System resonates at 7.15 MHz.

In a second comparison, the half-square array was compared with a roof-mounted trap vertical with eight radials. Again, in virtually every case, the half-square array was superior. The half-square's superiority was 3 to 5 S-units.

In my own application, the half-square was compared with a center fed 130-foot (40-meter) dipole, at 35 feet (10.7 meters), using balanced wire feed and a tuner. During the day, the systems were nearly equal, with a slight edge given to the dipole. As soon as the sun set, however, the half-square array emerged as a truly superior, if not an amazing performer. My half-square pattern is broadside east-west. I frequently operate between 1130 and 1300Z from fall through spring. Each morning, I work approximately five to ten JAs with a mean signal report of 589 using a kW. In addition, I have worked VKs, ZLs, H44, and YB9 as well as other scattered Pacific and Asian countries. In the recent CQ WW phone contest, I was able to compete in the pileups with the "big guns" for the very first time. It was rare for me to make more than four attempts to raise anyone. Countries in Africa and Europe were worked during the test as well as in Asia and the Pacific.

closing remarks

It seems we may have hit upon a complete antenna for a variety of Amateurs. It has proven to give high performance for DX as well as being more than adequate for normal use. It is efficient and easily fed. The half-square array is economical both in terms of initial investment and multiband applicability. The next time you get the bug to experiment with an antenna, try the half-square array. It may end your experimental urges (because of its high performance), or it may further stimulate you to try the extended approaches of parallel arrays recommended by the original author, Ben Vester. See you on 40, 160, 80, 20 and 10.

acknowledgment

I wish to thank KØCQ for advice as well as AIØZ and WDØERH for their hours of comparisons and willingness to try something new with something old.

reference

1. *The ARRL Antenna Anthology*, American Radio Relay League, 1978 edition, pages 81-83.

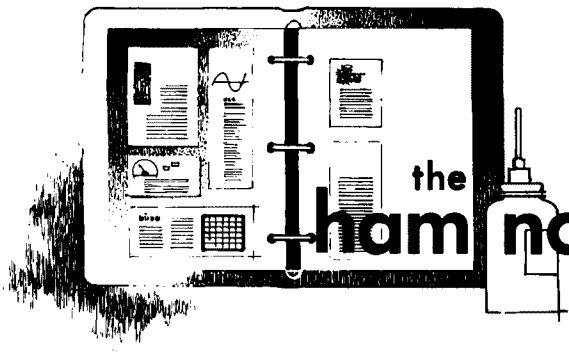
bibliography

Mitchell, Dennis, K8UR, "Antenna Engineer — Predict Performance of Phased Arrays with a TRS-80," *73*, May, 1980.

Swank, Jerrold A., W8HXR, "The Twenty-Meter Double Bobtail," *73*, May, 1980, page 44.

"Simple Arrays of Vertical Antenna Elements," *The ARRL Antenna Anthology*, American Radio Relay League, 1978 edition, pages 114-119.

ham radio



the ham notebook

extending the range of the K9LHA 2-meter synthesizer

Although my CMOS 2-meter synthesizer, described earlier in *ham radio*,[1] tuned only 146 to 148 MHz, capability was designed into the circuit and circuit boards for wider coverage. This was mentioned in my article, and it prompted a number of letters asking how to add 144-146 MHz coverage. Until recently I'd not tried using that capability for a wider tuning range and could only indicate how the design was planned. Now, having actually modified a synthesizer, I'd like to share the results.

extending frequency coverage

Extending the range of my synthesizer involves the addition of one or two switches and some minor circuit changes as follows:

1. Remove the jumpers under U1 connected to pins 8 and 9.

2. Connect the range switching circuit of fig. 1 to the input pads next to pins 8 and 9 of U1.

3. Change crystal Y2 to 47.3333 MHz.

4. Change crystal Y1 to *Y1 freq. = (47.3333 − i-f/3) MHz. If i-f = 10.7 MHz, Y1 freq. = 43.7666 MHz.*

5. Increase C12 to 39 pF and retune the VCO for a tuning voltage of 1.0 volt at 144.000 MHz in both receive and transmit modes by adjusting T1 and C14.

6. Readjust T2 and T3 to the new crystal frequencies so that you don't overdrive the squaring amplifier (Q8/Q9). It may be necessary to increase R39 and R43 to 470 ohms or so, depending on the activity of your crystals.

7. Increase R25 to 1.5k.

So that you can understand the reasons behind these changes, or improve upon the changes if you wish, let me briefly explain their intent. First, I suggest you spend a few minutes reviewing fig. 2 and the numbers directly beneath it in the synthesizer article.[1]

potential problems

A mixer in the synthesizer loop means that there are two VCO frequencies that will produce the same output frequency from the variable divider. Unfortunately, one of the two frequencies causes the phase detector to push the VCO away from, rather than toward, lock. In fact, lock will not occur unless it's forced in some way; preventing this condition is crucial in the design. One method is to restrict the VCO tuning range so that the wrong frequency cannot be reached; another is to select a high mixer i-f, so that the desired and image frequencies are separated as much as possible. The receive/transmit pulling circuit also helps since it

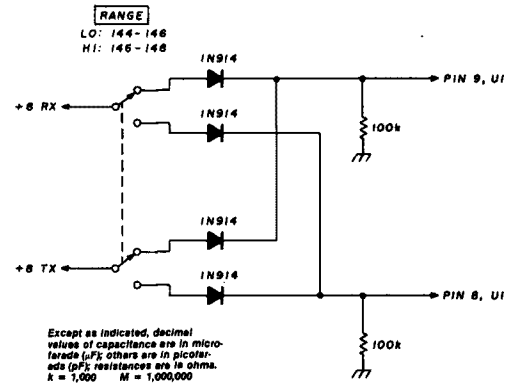


fig. 1. New range switch.

permits use of two, more precisely controlled tuning ranges for the VCO.

Because the desired and image VCO frequencies are separated by twice the variable divider input frequency (the "i-f"), the minimum divide ratio plays a very important role in avoiding the unlock problem. Unfortunately, while a large minimum divide ratio is desired, dividers are limited in speed capability, and a compromise is necessary. I found a value of $N = 400$ worked fine in my original design as well as in the full-coverage version.

The formula in fig. 2 (reference 1) shows that both receive and transmit crystals (Y1 and Y2) must be changed to cover the new frequency range, and the new frequencies are shown here. When the new crystals are installed the oscillators can be retuned.

The nature of these oscillators is such that they must be tuned to the high side of the crystal frequency to ensure reliable starting. The slugs of T2 and T3 also serve to adjust the output level from the squaring amplifier (Q8/Q9).

tuning transformers T2 and T3

In making this adjustment, I found that the squaring amplifier behaved very badly if overdriven at the upper range of frequencies. It is therefore important that T2 and T3 be set so that the squaring amplifier *just reaches* clipping level. I also noted that T2 and T3 had to be detuned considerably from resonance. This resulted in an error in oscillator frequency. To allow tuning closer to resonance it was necessary to increase the value of the two emitter resistors, R39 and R43, to reduce oscillator output. Again, your need to do this will depend upon the activity of your crystals.

Although retuning alone allowed the VCO to cover the full 144-148 MHz range, the tuning voltage came uncomfortably close to the supply voltage at the top end. Since I wanted to keep the tuning voltage within 1.0-5.0 volts to allow for temperature drift, I made a slight increase in the padder capacitor value, C12.

After tuning the synthesizer to the top of its new range, I found loop stability had been degraded and settling time was much too long. Therefore I increased the loop-filter damping resistor, R25, to 1.5k. A check with an f-m broadcast receiver showed that this change did not make any audible increase in sideband noise on the synthesizer output.

variable divider

The variable divider needs additional control inputs applied to pins 8 and 9 to tune the synthesizer over twice the range, as before. While it's possible to use another thumbwheel switch section for the MHz digit, the code required is not BCD; and a code-changing scheme would have to be used. The approach in fig. 1 is simply to use an additional toggle switch to choose between low (144-146 MHz) and high (146-148 MHz) ranges. Although this makes it a bit more difficult to read the operating frequency directly, the cost and complexity are much reduced. If you feel there's no need for receive and transmit frequencies on opposite sides of 146 MHz, only one range switch is required. The input to the switch comes from +8 (*not* +8RX or TX), and the four diodes are not needed.

Here's hoping this information will help builders who wanted full band coverage. It's been fun hearing from builders of my synthesizer, and I'm interested in both their successes as well as problems. As before, I'll be glad to answer questions if accompanied by a self-addressed, stamped envelope.

I have plenty of the VCO coil forms ($1, postpaid, including wire), and I understand that RadioKit still has the circuit boards and parts available.*

*RadioKit, Box 411, Greenville, New Hampshire 03048.

reference

1. Tom Cornell, K9LHA, "CMOS 2-Meter Synthesizer," *ham radio*, December, 1979, pages 14-22.

Tom Cornell, K9LHA

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medium-scan television

Recent developments in an interesting Amateur Radio communications mode

By Dr. Don C. Miller, W9NTP, RR1, Box 95, Waldron, Indiana 46182

In 1958 when Copthorne MacDonald began experimenting with the fundamentals of slow-scan television, it was assumed that the only kind of image that could be sent over the high-frequency Amateur bands was unimportant, low-resolution still pictures. Time has passed, and it has turned out that even though the pictures are of relatively low resolution, now in color, they serve a very important place in Amateur communications.

With the low cost of digital memory today, it is certain that higher resolution digital scan converters will be designed and built that will improve the present quality of pictures by at least one hundred percent. Most of us today know that the original analog system did have more resolution than present day digital scan converters.

The real compromise in SSTV is the lack of motion. There is a great amount of information in each frame of television so that when many frames are transmitted giving motion, the required bandwidth is prohibitive. About the only hope that the Amateur has to transmit motion and still keep the bandwidth within legal allocations is to examine the image for electronic sampling "tricks" that can be used to increase the apparent motion.

background

In 1978 a group of Amateurs consisting of WØLMD, W9NTP, WB9LVI, W3EFG, and W6MXV applied for a Special Temporary Authorization (STA) from the FCC to test a narrow band MSTV system on 10 meters. Mathematical analysis easily shows that even a few fields per second of motion will require more than the normal amount of voice bandwidth, which is assumed to be about 3 kHz. It is very easy to calculate the required bandwidth. It will first be assumed that the horizontal and vertical resolution of MSTV will have 128 pixels per horizontal line and 128 lines per frame. Since it takes two pixels (one black and one white to approximate a sine wave) for each Hz, the total amount of bandwidth is:

$$BW = \frac{128}{2} \times 128 \times number\ of\ frames\ per\ second$$

The early experiments concerning motion showed that the minimum number of frames per second to give acceptable motion is 7.5. This results in a bandwidth of 65.5 kHz. The only place that bandwidths of this size can be found in the high-frequency part of the spectrum is on 10 meters. The FCC STA request was actually for as large a spectrum bandwidth that could be obtained. When the STA was granted, it showed that only 36 kHz were available in the vicinity of 29.0 MHz. All tests have since been performed on 29.150 MHz.

bandwidth restrictions

Several problems immediately surfaced when MSTV was considered to be restricted into this bandwidth. First of all, rf-transmission is almost always twice the base video bandwidth that is calculated by the above formula. Even if the video signal were transmitted as single sideband, it would not fit the 36-kHz spectrum allocation.

Several approaches are possible. Every parameter of the picture must now be considered to be vulnerable to restriction. If the motion were cut into one-half or one-quarter, the signal would fit into the 36-kHz band. Tests have shown that the picture becomes very jumpy and cannot really be considered true motion if the field time or frame rate is dropped much below 7.5 frames per second.

There are many other parameters that can be changed to keep the video low in bandwidth and still give apparent motion on the screen. Tests have been made in which the picture was divided into quarters. Only one fourth of the picture was transmitted at any

one time. Other tests divided the picture into strips and transmitted one strip at a time. Still other formats sent every other line and combined the two transmissions similar to commercial interlaced television. All these schemes achieved the required 36-kHz bandwidth but left serious objectional artifacts on the screen that bothered the viewer.

The most ambitious test was to build a system employing a microprocessor that compared one stored image to a new image stored at a later time. The advantage of this system is that once the original image has been transmitted, only the changes need be transmitted in the future. Provision was made for periodic updates if the original picture had suffered interference. This system certainly works, but it is questionable that it could be made to work in a noisy, 10-meter-band environment. There is also the problem of transmitting the addresses of the changed pixels, which are liable to consume as much time and bandwidth as the redundant parts of the picture. I concluded that a better system for the Amateur is one that has a periodic update in all parts of the screen that is scanned into the memory rather than one that is addressed.

The Special Temporary Authorization (STA) permission from the FCC, which has been in effect from 1978, has been renewed by the FCC for an additional two year period. The original five Amateurs (plus one additional) have been given permission to transmit MSTV on 29.150 MHz with a maximum bandwidth of 36 kHz. These six Amateurs are WØLMD, W9NTP, WB9LVI, W3EFG, W6MXV, and NØAB. During these two years additional Amateurs can be added to the list. Each case will be considered by the FCC when permission is requested. I will be glad to work with anyone in preparing a request if they enlist my help.

Mathematical analysis shows that the maximum field rate that can be used for MSTV under these bandwidth restrictions is two fields per second for a 128-pixel by 128-line television picture. This results in a base video bandwidth of 16 kHz. One exception to this is the use of wideband single sideband. This will be considered in due time when a source of proper filters is located.

Since the last update, various motion formats have been tried, and some of the best ones were chosen for further tests. These tests have shown that if the full raster is transmitted, it is necessary to have an effective rate of at least 7.5 fields per second to give the illusion of reasonable motion. The 7.5 fields per second can be achieved easily by field grabbing at one eighth of 60 fields per second. The base bandwidth of such an image is 64 kHz, which is far beyond the capabilities of the allocated 36-kHz rf bandwidth.

early work

Some years ago one of the MSTV investigators, W3EFG, developed a bandwidth-reduction system called Sampledot for his employer (General Electric Company). The scheme was demonstrated in various mechanizations for several years. Sampledot works on the principle of transmitting only a fraction of the total number of pixels during any fast scan (60 Hz) field time. The chosen pixels for transmission are sampled from numerous small areas that are repeated many times throughout the total field time. The samples are taken in a pseudo-random fashion to reduce any repeated lines or edges that could result from regular sampling times.

The result is that, since each pixel is not transmitted every time the original field is scanned, the chosen pixel can be stretched in time, or "boxcar'-ed," to reduce the base video bandwidth. All the pixels in the entire field will be sampled after many pseudo-random passes through many different 60-Hz field times. The effect is to give continuous motion on a one partial field basis at less than 60 fields per second.

recent work

Recently, in the laboratory where various forms of adaptive picture bandwidth reduction were being tested, we set up the old Sampledot scan converter, which had also been converted to a field-grab system for comparision. Other digital scan converters were also available, to make it possible to demonstrate both Sampledot and field-grab systems simultaneously. A digital scan converter makes it possible to use field rates of other than 60 Hz for further bandwidth reduction. These two scan converters were coupled together to permit the demonstration of a Sampledot image derived from a 7.5-Hz field-grab image.

The image that viewers liked, in terms of minimum bandwidth, was a 4/1 Sampledot image at a field rate of 7.5 Hz. This gives a potential bandwidth reduction of 8×4, or 32. When divided into the 60-Hz field rate of the source television image, it results in an effective field rate of two fields per second, or a base video bandwidth of only 16 Hz (our objective for a transmission capability of 36-kHz rf bandwidth).

This experiment was based on a 128 × 128 pixel image. We feel that eventually the image should be 256 pixels by 128 lines. This means that the base bandwidth will be 32 kHz. If it evolves as wideband single sideband, the system of field-grab Sampledot will work out very well. Remember that no one has built this system yet, but the construction should be quite simple if you own a two-memory Robot 400. See the January 1981 issue of *QST* for how this can be accomplished.

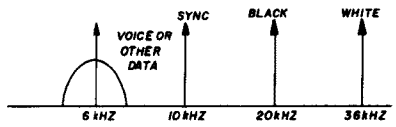


fig. 1. Proposed spectrum arrangement for the MSTV fm system.

SSB or fm?

The next standard to be set is the choice of transmission mode. Theory dictates that the maxmium base bandwidth signal that can be transmitted through a 36-kHz rf bandwidth is 18 kHz. Single-sideband techniques would raise this to 36 kHz. But it would also add many unknowns to the detection and generation process; so fm has tentatively been chosen for MSTV.

After much testing of SSTV standards back in the 60s, the originators decided upon a base bandwidth of 900 Hz, a synchronization frequency of 1200 Hz, and a white frequency of 2300 Hz. Using some of the same logic that was called forth to determine the SSTV standards, I would like to suggest as a starting point that a particular spectrum be used for further tests (see fig.**1**). If it is found later that other frequencies are more useful, it will be an easy matter to readjust the oscillators and discriminators for different standards.

reception and transmission

My suggestion for reception is the modification of an existing transceiver. Many tranceivers can be modified in this way; one example is the FT-101. This transceiver has an i-f output for spectrum analyzers or panadapters that is brought out ahead of the SSB filter. This low-level i-f signal can be amplified by means of solid-state amplifiers. The bandwidth can be limited with filters (active, passive, or special filters that you might find at hamfests). It does not mean that filtering must be done at the frequency brought out of the special i-f output. A simple mixer and oscillator circuit can translate the signal to the frequency of your favorite "bargain" filter (see fig.**2**). (According to information received from the "FOX-TANGO club," filters will be available from Yaesu.)

The detection can be done in a manner similar to that of the Robot 400. The tuned-filter discriminator works very well. The output frequency of some transceivers is in the 3-MHz band. Good high-frequency operational amplifiers could be substituted for the types in the Robot 400. Of course the active filter elements must be redesigned for the new wideband MSTV.

Fig. 2 also contains a block diagram of the suggested circuits for MSTV transmission. If you're interested in building circuits and testing them, get in touch with one of the six STA hams previously listed. We have no boards, just lots of messy connections on the bench, hundreds of ideas, and an enthusiastic, creative spirit reminiscent of the way ham radio "used to be." Test signals are put on the air every Saturday, for the first ten minutes of each hour, beginning when the 10-meter band opens (29.150 MHz). Call in after the ten-minute tests for the latest updates, or give us a call on the SSTV net each Saturday at 1800 GMT on 14.230 MHz.

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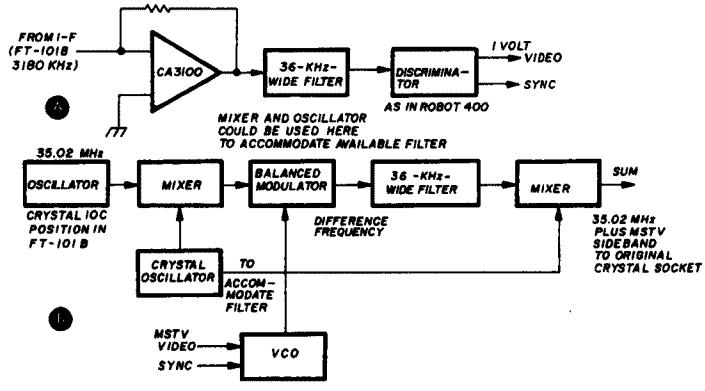


fig. 2. Block diagram for the proposed modifications to an FT-101 or similar transceiver. Conversions for receiver and transmitter sections are shown in A and B respectively.

short circuits

dip meters

In the article entitled "A New Look at Dip Meters," on page 28 of the August, 1981, issue, varactor diode CR2 in **fig. 7** should be rotated 180 degrees; otherwise the bias voltage will be returned to ground, and no tuning will occur.

The conversion factor for feet to meters in **table 1**, page 35 of the same issue should be 0.305, not 3.05 as shown.

transmission-line design

Unfortunately, several typographical errors crept into the mathematical equations in the article by H.M. Meyer, Jr., W6GGV, that appeared in the March, 1981, issue ("Transmission-Line Circuit Design, Part Four"). For an errata sheet, send a stamped, self-addressed envelope to *ham radio*, Greenville, New Hampshire 03048.

digital frequency display

The following corrections should be noted for the article "Digital Frequency Display For Single-Conversion Transceivers," which appeared on page 28 of the March issue. In **fig. 2**, U9 pin 14 should be connected to +5 volts, not to pin 13; pins 13, 12, and 8 should be tied together; pins 9 and 10 should be tied together. For U10-16, pin 14 on each should be connected to +5 volts, and in U10, 11, and 13 pin 7 of each should be connected only to ground. In **fig. 1**, note that, for U17-22, the grounded pin is pin 12.

operation upgrade

Part one of "Operation Upgrade" in the September, 1981, issue, contained an error. $Energy = EIt$, rather than EI/t. If $P = EI$ and $I = Q/t$, then $P = E\left(\frac{Q}{t}\right)$. To remove time and leave pure energy the formula would have to be $P = E\left(\frac{Q}{t}\right)$ *times* t.

digital techniques

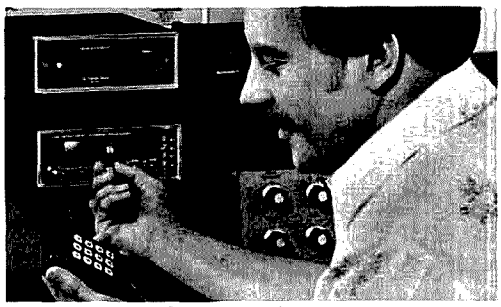
In part 1 of the article on digital techniques by W1BG (page 44 of the September, 1981, issue), the A input of the first counter in **fig. 4** should be at ground, not 5 volts.

FREE

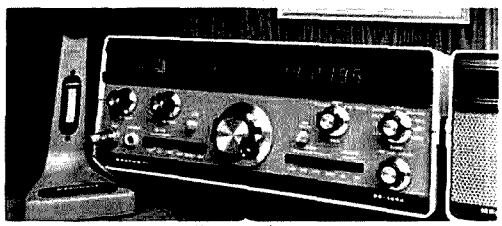
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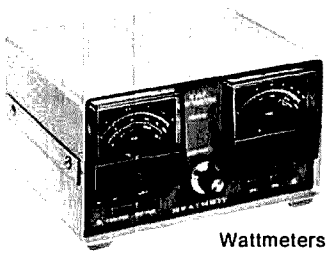
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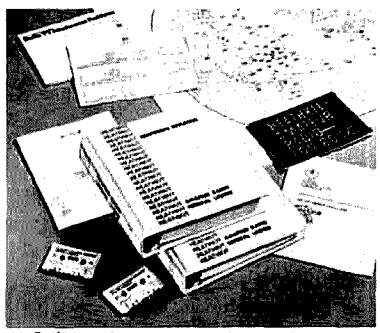
2-meter equipment



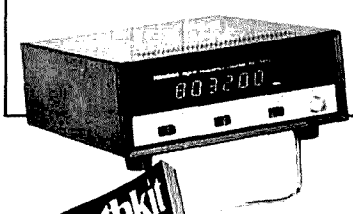
Transceivers



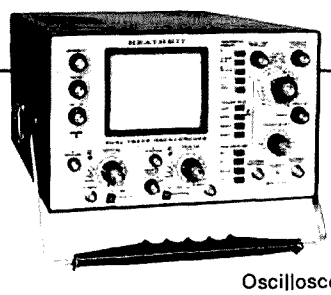
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More Details? CHECK — OFF Page 120

HAM CALENDAR

December

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
		AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **1**	**GEORGE WASHINGTON UNIVERSITY SCHOOL OF ENGINEERING & APPLIED SCIENCE** – Dr. Ulrich Rhode & Dr. Jack Smith will give a short course in frequency synthesizers. If interested, contact the Office of Continuing Engineering Education at the university. The course number is 866DC and the fee is $575. – 2-4. **2**	**3**	**PIKE COUNTY ARC & OLD POST ARS SPECIAL EVENTS STATION** – Call sign W9CZH. Time 0000 Z on Dec. 4 through 2300 Z Dec. 6. – 4-6.** **160 METER CONTEST** – 4-6. **4**	**17TH ANNUAL TELEPHONE PIONEERS QSO PARTY** – 1900 UTC, Dec. 5 through 0500 UTC Dec. 7. CW call CQTP. Phone call CQ Telephone Pioneers. – 5-7.** **5**
WEST COAST QUALIFYING RUN – 6. **HAZEL PARK ARC SWAP & SHOP** – Hazel Park High School, Hughes St., 9½ Mile Road, one mile east of I-75, Hazel Park, MI. SASE to Jack Field, WA8UPU. – 6. **6**	**WEST COAST BULLETIN** – 9PM PDT (8PM PST) 0400 UTC, 3540 KCS, A-1 22 WPM. **7**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **8**	**W1AW QUALIFYING RUN** 10. **9**	**10**	**11**	**10-METER CONTEST** – 12-13. **12**
W1AW Schedule October 25, 1981-April 24, 1982 MTWThFSSn = Days of Week Dy = Daily W1AW code practice and bulletin transmissions are sent on the following schedule: UTC Slow Code Practice MWF: 0300, 1400; TThS: 0000, 2100; Sn: 0300, 2100 Fast Code Practice MWF: 0000, 2100; TTh: 0300, 1400; S: 0300; Sn: 0000 CW Bulletins Dy: 0100, 0400, 2200; MTWThF: 1500 RTTY Bulletins Dy: 0200, 0500, 2300; MTWThF: 1600 Voice Bulletins Dy: 0230, 0530 EST Slow Code Practice MWF: 9 A.M., 7 P.M.; TThSSn: 4 P.M., 10 P.M. Fast Code Practice MWF: 4 P.M., 10 P.M.; TTh: 9 A.M.; TThSSn: 7 P.M. CW Bulletins Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M. RTTY Bulletins Dy: 6 P.M., 9 P.M., 12 P.M.; MTWThF: 11 A.M. Voice Bulletins Dy: 6:30 P.M., 12:30 A.M. CST Slow Code Practice MWF: 8 A.M., 6 P.M., TThSSn: 3 P.M., 9 P.M. Fast Code Practice MWF: 3 P.M., 9 P.M.; TTh: 8 A.M.; TThSSn: 6 P.M. CW Bulletins Dy: 4 P.M., 7 P.M., 10 P.M.; MTWThF: 9 A.M. RTTY Bulletins Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M. Voice Bulletins Dy: 5:30 P.M., 11:30 P.M. PST Slow Code Practice MWF: 6 A.M., 4 P.M.; TThSSn: 1 P.M., 7 P.M. Fast Code Practice MWF: 1 P.M., 7 P.M.; TTh: 6 A.M.; TThSSn: 4 P.M. CW Bulletins Dy: 2 P.M., 5 P.M., 8 P.M.; MTWThF: 7 A.M. RTTY Bulletins Dy: 3 P.M., 6 P.M., 9 P.M.; MTWThF: 8 A.M. Voice Bulletins Dy: 6:30 P.M., 9:30 P.M. Code practice and CW bulletin frequencies: 1.835, 3.58, 7.08, 14.08, 21.08, 28.08, 50.08, 147.555 MHz. RTTY bulletin frequencies: 3.625, 7.095, 14.095, 21.095, 28.095, 147.555 MHz. Voice bulletin frequencies: 1.835, 3.99, 7.29, 14.29, 21.39, 28.59, 50.19, 147.555 MHz. On Monday, Wednesday and Friday, 1400 through 2200 UTC, transmissions are beamed to Europe on 14, 21 and 28 MHz. Slow code practice is at 5, 7 1/2, 10, 13 and 15 wpm. Fast code practice is at 35, 30, 25, 20, 15, 13 and 10 wpm. Code practice texts are from *QST*, and the source of each practice is given at the beginning of each practice and at the beginning of alternate speeds. For example, "Text is from February 1980 *QST*, pages 9 and 82" indicates that the main text is from the article on page 9 and the mixed number/letter groups at the end of each speed are from page 82. On Fridays, UTC, a DX bulletin replaces the regular bulletin transmissions. CW bulletins are sent at 18 wpm; Teletype bulletins are sent at 60 wpm with 170-Hz shift, then repeated on 110-baud ASCII. **13**	**WEST COAST BULLETIN** – 9PM PDT (8PM PST) 0400 UTC, 3540 KCS, A-1 22 WPM. **14**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **15**	**16**	**TRIPLE STATES RADIO AMATEUR CLUB** – will operate from Bethlehem, WV from 1400 to 2300 UTC daily. – 17-21.** **17**	**18**	**19**
	WEST COAST BULLETIN – 9PM PDT (8PM PST) 0400 UTC, 3540 KCS, A-1 22 WPM. **21**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **22**	**23**	**24**	 **25**	**26**
27	**28**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **W1AW QUALIFYING RUN** 29. **29**	**30**	**STRAIGHT KEY NIGHT** – 31.		

The months of fall, October and November, are possibly the most exciting months of the year on the DXer's calendar. The summer doldrums are over, and the noontime null caused by solar absorption is greatly diminished as the sun moves further south. Thunderstorms and their attendant QRN are far less noticeable, and 40 and 80 meters are really snapping back to life.

Spring is in full sway in the Southern Hemisphere. As the sun crosses the equator, paths worldwide improve, giving DXers everywhere shots at far-flung places. Ten meters is hotter than a pistol, bringing new thrills to its devotees, while 15 to 20 are really strutting their stuff.

On the other side of the ledger are the spate of solar disturbances. The period after a peak in the sunspot cycle is the worst for frequent solar upheavals, which can devastate conditions for days on end, especially on the higher frequencies. Still, the storms peak out in the summer months and their intensity fades as we head into the months of late fall.

I settle into the operating chair and adjust the headphones till they're comfortable. I glance over at my chalkboard, knowing what I'll find — very little. A couple of forlorn notes on VK9NV, now over three months old. He seems to have disappeared from the bands. Maybe the incessant pileups of Japanese, American, and European DXers finally got to him. I guess I couldn't blame him if they did. But it sure doesn't help me if he's given up operating.

There's a note on the DXpedition to S9R, Sao Thome, West Africa. But yesterday's "DXer's Tout Sheet" said that the operation was going to be delayed at least six weeks, and very possibly would have to be cancelled. It figures; I need that one.

I move the bandswitch to 20 meters. Let's put the antenna on NNE, bisecting the paths to Europe and the transpolar route. It's 0000 Zulu. Europe will probably still be coming in if conditions are any good, and the path across the pole should be opening right now as morning sunlight chases the MUF up from its dog-watch lows.

I set the receiver right at the bottom edge of 20, at 14000 kHz, and start tuning up the band. It's Friday night, so there's hope of increased activity all over the world.

Hah. There's G3FXB, in QSO with somebody, *just* starting a transmission. I listen, but it becomes obvious that Al is well into a ragchew with someone. I listen to that fine fist, 30 or 35 words per minute and music to the ear. Al's one of the top dogs in the DXCC program Honor Roll, a fixture on the lists for many years. Al is active, and that's part of the secret of staying on top. He's always operating contests, usually in rivalry with his close friend G3MXJ. In between contests, Al is often heard ragchewing.

A chat with Al would be nice if nothing is happening on the band. I set my extra VFO on his frequency as a marker, so that I can easily find him again, and continue tuning higher up the band.

There's a good strong signal calling CQ. Almost instantly I recognize it from the fist: it's VU2BK. A retired Indian Army officer, he's very active on the bands and generally the strongest signal from India. I pause and take a close look at his signal. I don't need a contact but a look at his signal can tell you a lot about the band. The very fact that I'm copying him at all says something, and his S8 signal sure adds to the assessment that the band is in fairly good shape at the very least. Hmm. No trace of auroral buzz, and, really, very few of the usual characteristics of a long-haul signal. The really long-haul signals, while pleasant to listen to, often have telltale marks impressed on them that disclose their long-haul origins. These include subtle but continual tiny shifts in frequency (Doppler shifts) caused by the slightly different paths delivering the signal, softened keying characteristics caused by the time delay differentials of the different paths — and often at least a trace of auroral buzz.

No, this signal is very clean and pretty strong, which indicates good conditions and that his primary path is overwhelming the marks and signatures secondary paths would add.

One of the games that any DXer, but especially a CW operator, constantly has to practice is identifying whether a signal is DX or not without hearing the call, so that, while tuning a band, time won't be wasted waiting for domestic stations in QSO to sign. The ability to quickly read that aspect of a signal is invaluable in contest and pileups as well.

A trained operator, even listening to a stateside station in QSO, can usually figure out whether the station you hear is into a good one; there are few operators who don't show excitement when working a new one. It's a subtle thing on CW, but it's still noticeable. The tip-off is timing. A fellow who's in contact with what is for him a new country usually has a very choppy timing and spacing on his fist, reflecting his excitement, and the world's best keyer won't cover it up.

Of course, the new one for him might be the fellow that you've been ragchewing with every Wednesday night for the last two years, or it could be a guest operator at some big gun's station experiencing the thrill of his very first DJ QSO, but whenever you hear the signs that someone is excited about his QSO, you have to wait and see who he's got.

I keep moving the receiver slowly up the band. Hmmm. There's a loud and raucus signal. Obviously an intruder, not an Amateur station at all. Some exotic form of modulation, something that no ham ticket anywhere in the world would authorize for 20 meters. And not only is the sig-

nal 20 dB over S9, but it has nasty little sidebands as well, making the signal over a kHz wide. Probably a Moscow to Havana circuit. Oh well, it's a good place to tune up my rig, where no legitimate ham will be bothered. I move the rig up, key down and check output and SWR. All's well. I tune on up the band, getting clear of the sidebands of that illegal intruder.

The receiver dial tells me that I'm just above 14,050. I start to spin the dial back down, but stop. I've been covering the slot of 14,000 to 14,050 regularly for a long time, and recently, with very little to show for it. That area is where the action usually is, but what the heck, let's tune higher.

As with almost every band, the higher on 20 meters you go the slower the fists, in general. It seems as if the newcomers are afraid of getting blown away by hot-shots down at the bottom end of the band, and so they stay higher up. It's a good practice, just like the swimming pool; practice your strokes in the shallow end before you high dive into the deep end.

And DX stations do the same thing. So, perhaps a good one can be dredged up by working the high end. My tuning up this high in the band is slower, but still very interesting.

Almost immmediately I come across a goody; a slow, hesitant fist, not too strong, "CQ CQ DE SV9MT SV9MT KN." Crete, a nice catch, though not one I need. I chuckle at the KN at the end of his CQ; obviously a newcomer, but he'll learn. The first couple pages of my first log book show me giving reports of 995.

As I pick up the 2-meter microphone I hear him start a CQ again. I call it in.

"Hey, I've found Crete on 20 meter CW, that's SV9MT, Sugar Victor Nine Mexico Tango, fourteen oh sixty eight, fourteen oh sixty eight, from W9KNI."

"Hey, W9KNI, here's WD9IIC. Bob, I need that one, but I've got my station all torn apart. I can be back on in five or ten minutes. Are you working him?"

"WD9IIC from W9KNI. OK, Dick. Nah, he's calling CQ, and not getting any takers. I don't need him, but I tell you what. If nobody comes back to him after the call he's making now, I'll try to work him and hold him for you. He's going real slow, so if I get a QSO, you'll have ten minutes for sure. OK?"

"Fine, Bob. That would be real nice. 'Preciate it, I'll get my stuff together here quick. W9KNI from WD9IIC."

"Rah-jer."

I listen to the SV9 — there, he signs. I listen closely. Yes, someone is coming back to him — about the same strength — sounds like another European. Yes, it's a DF9, a German, going nice and slow, almost dead zero on the SV9. He signs.

The SV9 starts up, coming back to the German. I pick up the 2-meter microphone again.

"OK, Dick, you got a reprieve. A DF9 got him. You want I should watch the frequency till you're ready? WD9IIC from W9KNI, go ahead."

"OK, Bob, thanks. W9KNI from WD9IIC. I've got the receiver working again now and I'll have the transmitter hooked back up in a couple minutes. Let me find that fellow now, so that you won't have to sit around and wait. What was that frequency again?"

"Ah, he's on fourteen oh sixty eight. He's going real slow, and he's pretty much in the clear."

"OK, the one saying QTH HR CRETE? Yup, that's got to be him. OK, Bob, I'm all set. Thanks again. W9KNI from WD9IIC."

"Yeah, good hunting, Dick. W9KNI clear."

I start tuning higher again. Hmm. OK, there's fellow really clipping along; got to be at least sixty words per. A keyboard artist, for sure. Yeah, he signs it over; it's W9TO with a W6. And right next to him, just above him, a slow, steady CQ, a DX station almost for sure from the sound of it. I keep listening. Yes, it's LX1TK, Luxembourg. Not really rare, but not common either.

I decide to see if Dick caught the SV9 yet. I touch the VFO spotting button and move the receiver to the frequency. Right on time, too. There's the SV9 signing clear with the DF9.

WD9IIC starts calling, dead zero on the frequency that the DF9 was on. But so is someone else. I pick up the 2-meter mike, "WD9IIC from W9KNI. Hey, you got competition, Dick. Make it a l-o-n-g call. I'll tell you when to stop."

I listen. Dick keeps signing his call. The other station ends his call. "OK, Dick, two more times, two more times."

Just as Dick ends, the other station realizes that the SV9 hasn't come back and starts calling again. But it's too late. He's been had. The SV9 starts coming back to WD9IIC.

"Way to go, Dick!"

"Thanks, Bob." Dick's response is brief; he's busy copying.

It's a good feeling to help a friend get a new one; almost as exciting as working a new one for yourself. The sense of pride feels good. And, at times, a little coaching on 2 meters can make all the difference.

Yes, Dick is in solid with the SV9. I call it in again on 2 meters, then resume tuning higher up the band.

There's 9TO again, still burning up the frequency. And there are six or eight stations calling the LX. Funny how they'll pick up on something like the LX and miss the rare SV9 a few kHz away. But it happens all the time.

Another CQ. OK, it's an EI. Someone calling a KP4; yes, an SP9. Hmm. Someone promising a direct QSL, wait and see what that one's about for sure. There.

"GJ4CTS DE WD4KHJ." I call the GJ4 in on 2 meters — not terribly rare but someone might want it. Nobody asks for a repeat, so I tune on.

A loud teletype signal tells me that perhaps I'm a little high. I look at the dial. Yup, I'm at 14087. OK. I decide to move back to 14050 and start up again. This end of the band seems interesting tonight.

"Hey, Bob, thanks a lot. That was a new one for me. Hope that I can re-

pay the favor. W9KNI from WD9IIC."

"Ah, great, Dick. WD9IIC, here's W9KNI. Fine. Hey — you can pay me back. I need Kamaran. I'll be on for another twenty minutes or so; find me one before I QRT, OK?"

"Hah. OK, I'll start now. Thanks again."

"Yeah, you do that! See you later."

I glance at the antenna rotor control; still set between the paths to Europe and the transpolar route to deep Asia. I haven't heard anything on the transpolar path except the VU2 earlier. I decide to swing the antenna a bit further south, to 45 degrees, dead on Europe. I'll still hear the transpolar signals, though perhaps an S-unit weaker, but, on the other hand, I'll have a better chance of hearing Africans.

I keep tuning higher, listening carefully as I go. There's an ISØ on Sardinia, working a PY in Brazil. There's a bit of a pileup; I listen. OK, it's various European stations chasing an HP1, a Panamanian.

There's a Frenchman calling CQ. There's a UP2 calling a WD4. There's another CQ, a slow one, using a hand key for sure. There, he's signing. His fist is a bit difficult. G8AL? No, that can't be. Sounds like it though. He's calling CQ again. Can't be a G8. Could it? There, he's signing again. Let's try it again. Hey! Hey! It's a TN8, not a G8. TN8AL, the Congo, and one I need. I didn't know that any one was on from there, but here one is.

Pull the VFO up zero on him. Turn on the linear. Zapp! It's up and running. He continues his CQ call, obviously a new operator. I move the VFO just above him and key down for a moment. Yes, everything is OK as I trim the drive level of the exciter. OK, re-zero him. Move the antenna. I glance at my great circle map on the wall. OK, 80 degrees should be close enough. There, he's signing again. Yes! It's definitely TN8AL. OK, he's done.

I pause a moment, Yes, there's someone else calling him, but he's 300 or 400 hertz off. I start my call — oops. Thirty or thirty-five words per minute is a little fast for a new fellow sending perhaps twelve! I move the keyer speed. That's better.

I give a two-by-three call; "TN8AL TN8AL DE W9KNI W9KNI W9KNI AR K." I stand by.

The frequency is silent. Then the other station that was calling the TN8 starts to call again. I pause a moment longer. But, just as I'm about to start a second call, I hear:

"W9KN W9KN?" DE TN8AL TN8AL K K K." A new operator, for sure. I call again.

"R TN8AL TN8AL DE W9KNI W9KNI W9KNI KNI KNI W9KNI AR KN."

I wait. A long pause. There, he starts again.

"W9KNI W9KNI . . ." Great! He's got my call OK now . . . "TN8AL R HELLO OM ET MERCI EEEEE TNX QSO RST 489 489 QTH BOX 1293 BOX 1293 BRAZZAVILLE BRAZZAVILLE NOM CAMTI CAMTI OK? W9KNI DE TN8AL KN KN."

Wow!

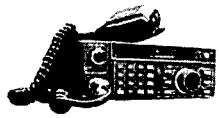
"R TN8AL DE W9KNI . . ." Hmm. This fellow obviously speaks more French than English. Not surprising.

"MERCI CAMTI POUR LE QSO ET VOTRE RST 579 579 PRES DU CHICAGO QTH PRES DU CHICAGO ET NOM EST BOB BOB QSL SVP MA QSL BOX 1293 OK SURE RIG 600 WATTS ET YAGI WX 6C 6C TRES FROID HI HI OK CAMTI? TN8AL DE W9KNI AR KN."

"R W9KNI DE TN8AL R FB CHER AMI BOB ET MERCI POUR LE QSO RIG 100 WATTS ET DIPOLE QSL SURE 73 A BIENTOT SK W9KNI DE TN8AL SK."

"R 73 CHER AMI CAMTI ET BONNE CHANCE A BIENTOT DE W9KNI SK EE."

The slow QSO has given me time to get all the log data written while he was transmitting. I listen — no one is calling him except the fellow that I beat out when he was calling CQ. But I can change that. I pick up the 2-meter microphone . . .

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AKAI VC100 TV camera (s/n U51115-90033) and VM100 monitor (s/n U51115-9078). Need schematics, service manual or connection instructions. Will pay postage both ways or xeroxing costs. Peter Simpson, KA1AXY, 18 University Drive, Natick, MA 01760.

WANTED: Heath IT-5283, IG-5282, IM-5284, IT-5230, CRT, checker, CMA-1550 engine analyzer, IP-2718, IP-2717, IT-5235, IC-5228, IT-3120. E. Tanrath, 3035 LaSalle Avenue, Rockford, IL 61111. (815) 877-0883.

SATELLITE TELEVISION...HOWARD/COLEMAN boards to build your own receiver. For more information write: *Robert Coleman, Rt. 3, Box 58-AHR, Travelers Rest, SC* 29690.

Coming Events

PLAYBOY CLUB: Plan ahead now to attend the ARRL Hudson Division Convention, October 30-31, 1982, at the Playboy Club, Great Gorge, McAlee, NJ. For info send SASE to HARC, Box 528, Englewood, NJ 07631.

ILLINOIS: Wheaton Community Radio Amateurs Hamfest will be held February 7, 1982, at Arlington Park Race Track EXPO Center, Arlington Heights, Illinois. Free Flea Market tables and expanded floor space. Large commercial area including the new "computer" section. For commercial info call WB9TTE at 312-766-1684; for general info call WB9PWM at 312-629-1427. Clear paved parking. Awards. Tickets $3.00 at entrance, $2.50 in advance. Send SASE to WCRA, P.O. Box QSL, Wheaton, IL 60187. Talk-in on 146.01/61 and 146.94. Doors *open* 8 AM. Be There! — KA9KDC.

SOUTH BEND, INDIANA Hamfest Swap & Shop, January 3, 1982, first Sunday after New Year's Day at Century Center downtown on U.S. 33 ONEWAY North between St. Joseph Bank Building and river. Industrial history Museum in same building. Half acre carpeted in one room. Tables $3 each. Four lane highways to door from all directions. Talk-in Freq: 52-52, 99-39, 93-33, 78-18, 69-09 and 144.83-145.43.

VIRGINIA: The Richmond Amateur Telecommunications Society's annual "Frostfest," Sunday, January 10, Virginia State Fairgrounds, Richmond. Gates open 8 AM. Activities include CW and Homebrew contests. Admission: $3.00. Flea market tables extra. Major prizes awarded promptly at 3 PM. For information: Joe Stern, (804) 737-0333.

OPERATING EVENTS

DECEMBER 17 TO DECEMBER 21: The Triple States Radio Amateur Club will operate from Bethlehem, West Virginia from 1400 to 2300 UTC daily. Frequencies for WD8DDL/8 will be: 7.275, 14.325, 21.425 and 28.550 MHz on SSB. 7.110, 14.075, 21.110 and 28.110 MHz on CW. For a special holiday season card SASE to TSRAC, 26 Maple Lane, Bethlehem, Wheeling, WV 26003.

JANUARY 1, 1982. Worked All Hawaii Awards available to all licensed Amateurs. Sponsored by the Big Island Amateur Radio Club. Contacts after 0000Z. Any mode, any band. Three classes. Class A: Work 100 Hawaiian stations. Class B: Work 50 Hawaiian stations. Class C: work 25 Hawaiian stations. Award fee $3.50 U.S. Address award applications to: Big Island Amateur Radio Club, P.O. Box 1688, Kamuela, Hawaii 96743.

JANUARY 17: The Phil-Mont Mobile Radio Club Station W3TKQ will be celebrating its 30th anniversary and commemorating the Club's association with the Franklin Institute and the birthday of Ben Franklin, Philadelphia's First Citizen. Station will operate 80 through 10 meters from 8 AM to 8 PM. A special QSL card/certificate for a SASE. Frequencies: lower edges of the General and Advanced bands.

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L-75 160-15M 1.2KW Linear	List $699	SALE $ 619
RV-7 Remote VFO for TR-7	List $195	SALE $ 175
MS-7 Speaker for TR-7/R-7	List $49	SALE $ 45
MN-75 200W PEP 150-10M Tuner	List $259	SALE $ 229
MN-2700 2KW PEP 180-10M Tuner	List $349	SALE $ 319
CS-7 Remote Antenna Switch	List $169	SALE $ 149
WH-7 20/200/2000 Wattmeter	List $129	SALE $ 116
DL-300 300W Dry Dummy Load	List $27	SALE $ 25
DL-1000 1KW Dry Dummy Load	List $53	SALE $ 49
AK-75 Multiband Antenna	List $40	SALE $ 37
7000E Communications Terminal	List $1095	SALE $ 979
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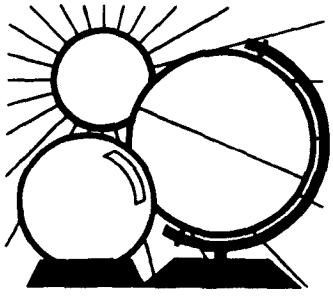
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DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

The 27-day solar maximum is expected to peak around the middle of the month, which leaves the beginning and end of the month with lower flux and flare activity. Geomagnetic disturbances can be expected about December 1, 11, 20, and 28. The two mid-month disturbances are solar flare effects, and the others are from coronal hole thinness, increasing the solar wind. From these solar/terrestrial relationships, the best DX is probably going to be at night on the lower-frequency bands during the first week and a half. Then the higher bands will be favored for long-haul DX for the next week and a half. DX conditions may be poorer during the last week and be best on the lower bands again.

December is probably the best month for winter DX. Although the hours of daylight are quite short now in the Northern Hemisphere, the ionosphere-propagated frequencies rise rapidly, with the rising sun, to the higher frequency bands of good DX. The sunspot number and solar flux remain high enough to ensure good MUFs during this winter DX season. The earth is closest to the sun, which results in a 5 percent rise in solar flux and ionospheric density during winter. December is also one of the quietest months of the year in terms of geomagnetic disturbances. Radio noise propagated from the thunderstorm centers over the few land masses of the Southern Hemisphere are far from us, so the 80- and 160-meter bands are good for daytime use and become good possibilities for DX during the long winter nights. All these conditions make for good DX. The longest night — winter solstice — is on the 21st this year.

The Geminid meteor shower, which reaches its peak on December 13-14, provides the richest and most reliable display of the year, with rates of 60-70 per hour (measured mainly by radio because of the poor weather in December). Also, a smaller portion of the shower (15-20 per hour) is observed on December 22. Lunar perigee and full moon occur on December 11.

band-by-band summary

Six meters will open occasionally during time of 27-day solar flux maxima. The openings will follow the sun — east before noon, south at noontime, and west and transequatorial during the evening.

Ten and fifteen meters will be like the openings on six, except more frequent and longer in duration. Worldwide DX will abound from after sunrise until well after sunset during periods of high solar flux (listen to WWV at 18 minutes after the hour for the daily flux value).

Twenty meters, the universal DX band, will be open most days during December this year, to most parts of the world during the day and into the night. Best conditions can be expected just after sunrise and just before sunset. Long skip will be available as the band opens upon sunrise, and will last until well after sunset.

Forty meters is a transition band between the daytime bands at high frequencies and the nighttime bands at this and lower frequencies. Our new 1979 WARC 30-meter band will provide the in-between band that may allow round-the-clock communications on 350- to 2500-mile (560-4000 km) paths. As is, 40 meters is very active to most areas of the world during hours of darkness to just before sunrise. In late afternoon, the band will open to the east, covering Europe, then swing around to the south at about midnight, and west to the Pacific by dawn. Short skip will be available on most days.

Eighty and one-sixty meters are expected to be excellent on this best month of the year for the top bands. Low noise during the long nights will give hours of pleasure if you are looking for the rare ones on these bands. DX from the coastal areas over water to South Africa, South America, and Australia-Asia will be easiest; but rare ones from anywhere will be worth the effort. You ragchewers on these bands try some DXing.

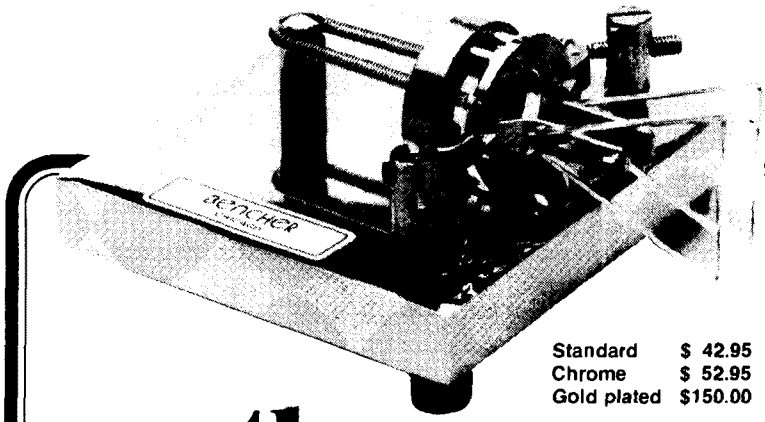
ham radio

*Look at next higher band for possible openings.

GMT	PST	WESTERN USA N	NE	E	SE	S	SW	W	NW
0000	4:00	10	20	10	15	15	10	15	10
0100	5:00	10	20	10	15	15	10	10	10
0200	6:00	10	20	15*	15	15	10	10	10
0300	7:00	15	20	15	15	15	10	10	15
0400	8:00	15	20	20*	20	15	10	15	15
0500	9:00	15	40	20	20	15	15	15	20
0600	10:00	20	40	20	20	20	15	15	20
0700	11:00	—	40	20	20	20	15	—	20
0800	12:00	—	20	20	20	20	20	—	20
0000	1:00	—	20	—	20	20	20	—	40
1000	2:00	—	20	—	20	20	40*	—	40
1100	3:00	—	—	—	40	40	40	40*	40
1200	4:00	—	—	—	—	20	40	40*	40
1300	5:00	—	—	20	20	20	40	40	40
1400	6:00	—	20	15	15	20	40	40	40
1500	7:00	—	20	15	10	20	40	20	40
1600	8:00	20	20	10	10	—	20*	20	40
1700	9:00	20	15	10	10	—	15	15	40
1800	10:00	20	10	10	10	—	15	15*	40
1900	11:00	20	15	10	10	—	10	10	20
2000	12:00	15	15	10	10	—	10	10	20*
2100	1:00	15	20	10	10	—	10	10	15
2200	2:00	15	20	10	10	—	10	10	10
2300	3:00	10	20	10	10	—	10	10	10

DECEMBER	MST	MID USA N	NE	E	SE	S	SW	W	NW	CST
ASIA FAR EAST	5:00	10	20	10	10	15	10	10	10	6:00
EUROPE	6:00	10	20	10	15	15	10	10	10	7:00
S. AFRICA	7:00	10	20	15*	15	15	10	15	10	8:00
S. AMERICA	8:00	15	20	20*	15	15	15	15	10	9:00
ANTARCTICA	9:00	20	20	20*	15	15	15	15	20*	10:00
NEW ZEALAND	10:00	—	40*	20	20	15	20*	20	20	11:00
OCEANIA AUSTRALIA	11:00	—	40	—	20	15	20	—	20	12:00
JAPAN	12:00	—	40	—	40	20*	20	—	20	1:00
	1:00	—	40	—	40	20*	20	—	20	2:00
	2:00	—	—	—	40	20	20	—	20	3:00
	3:00	—	—	—	40	20	20	—	20	4:00
	4:00	—	—	—	40	20	20	—	—	5:00
	5:00	—	20	15	40*	—	20	—	—	6:00
	6:00	—	20*	15	20	—	40	20	—	7:00
	7:00	—	10	10	10	—	20	20	—	8:00
	8:00	20	10	10	10	—	20	20	40	9:00
	9:00	20	15	10	10	—	15	20	—	10:00
	10:00	20	15	10	10	—	15	15	—	11:00
	11:00	20	15	10	10	—	15	15	—	12:00
	12:00	20	15	10	10	—	10	20*	—	1:00
	1:00	20	20	10	10	—	10	10	20*	2:00
	2:00	20	20	10	10	—	10	10	15	3:00
	3:00	—	20	10	10	—	10	10	10	4:00
	4:00	—	20	10	10	—	10	10	10	5:00

DECEMBER	EST	EASTERN USA N	NE	E	SE	S	SW	W	NW
ASIA FAR EAST	7:00	15	20	10	15	15	10	10	15
EUROPE	8:00	15	20	15*	15	15	10	10	15
S. AFRICA	9:00	15	20	15	15	15	15	15	15
CARIBBEAN S. AMERICA	10:00	15	20	20	20	15	15	15	20
ANTARCTICA	11:00	20	20	15	20	15	20	20	20
NEW ZEALAND	12:00	20	40	15	20	20	20	—	20
OCEANIA AUSTRALIA	1:00	20	40	15	20	20	40*	—	20
JAPAN	2:00	—	20	—	20	20	20	20	20
	3:00	—	20	—	40	20	20	20	20
	4:00	—	20	—	40	20	20	20	20
	5:00	—	20	20	40	20	20	—	—
	6:00	—	15	15	20	—	40	40	—
	7:00	20	10	10	15	20	80*	40	—
	8:00	20	10	10	10	—	80*	20	—
	9:00	20	10	10	10	—	—	20	20
	10:00	15	10	10	10	—	—	15	20
	11:00	15	10	10	10	—	15	15	—
	12:00	15	15	10	10	—	15	—	—
	1:00	—	15	10	10	—	10	10	—
	2:00	—	15	10	10	—	10	10	—
	3:00	—	20	10	10	—	10	10	40
	4:00	—	20	10	10	—	10	10	20
	5:00	15	20	10	10	15	10	10	15
	6:00	15	20	10	10	15	10	10	15



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TERMINALL

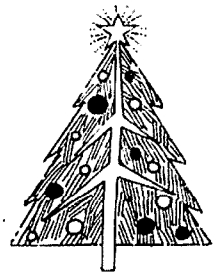
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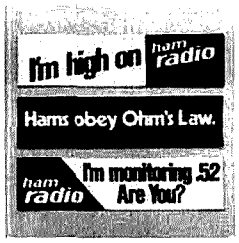


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Ham Radio's Ultimate Flea
GREENVILLE, NH 03048

software on cassette and disk, assembled and tested hardware, and an extensive instruction manual. List price is $999. For complete ordering information or name of dealer closest to you, contact Macrotronics, Inc., 1125 N. Golden State Blvd., Turlock, California 95380.

CW audio processor and keyer

Trac Electronics, Inc., announces the introduction of two unique products for the CW enthusiast. The TRAC*ONE CW processor, Model TE 424, is an advanced CW audio processor which receives the audio from any rig, passes it through a phased-locked-loop tone decoder, removing all QRN and QRM, and reproduces a fully adjustable CW audio signal. Front-panel controls allow full adjustment of frequency tone, delay, and gain. The frequency control is adjustable from 300 Hz to 2500 Hz, a match for any rig. While the CW signal is being decoded a front panel LED flashes in sync with the signal, establishing that the unit is locked onto the audio from the rig. The TRAC*ONE contains a built-in speaker and a headphone jack on the rear panel, and is operated on a 9-Vdc battery or with an ac-adapter. In the BYPASS position, the Model TE-424 TRAC*ONE may be left in line and the rig audio is passed through to the speaker.

The TRAC*ONE CMOS keyer, Model TE-464, combines the full featured TRAC*ONE with a deluxe state-of-the-art CMOS electronic keyer. The keyer contains self-completing dots and dashes, dot and dash memory, iambic keying with any squeeze paddle, 5-50 WPM, speed, volume, tune and weight controls, sidetone and speaker, rear panel switch for use with a bug or straight key, quarter-inch jacks for keying and output. The Model TE-464 keys both grid block and solid state rigs and operates on one 9-Vdc battery or a 9-Vdc/ac adapter.

For further information, contact Trac Electronics, Inc., 1106 Rand Bldg., Buffalo, New York 14203.

ham radio cumulative index

a note on this index

In an effort to give our readers as many articles as possible in this issue of *ham radio*, we have switched from a ten-year to a five-year cumulative index. By doing so we have made approximately ten additional pages available for feature articles. Those readers who wish to a see a cumulative index for years previous to 1977 should consult previous December issues of *ham radio*. Back issues are available from Ham Radio's Bookstore for $3.00 postpaid.

Please let us know what you think of this change, and whether you would prefer to see five- or ten-year cumulative indexes in future December issues of *ham radio*.

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